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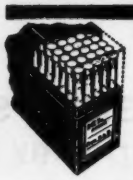

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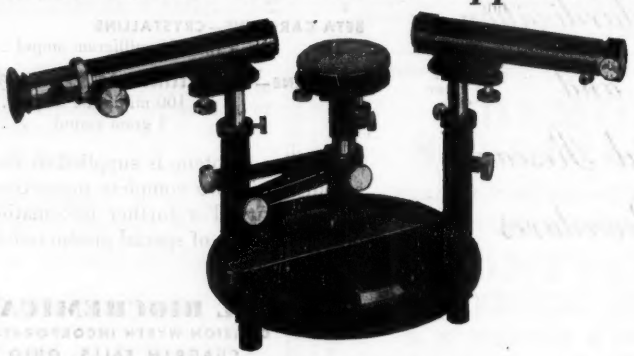

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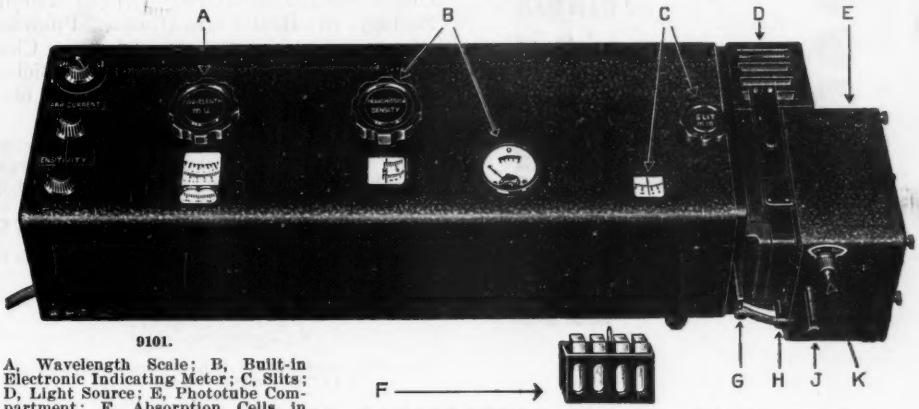

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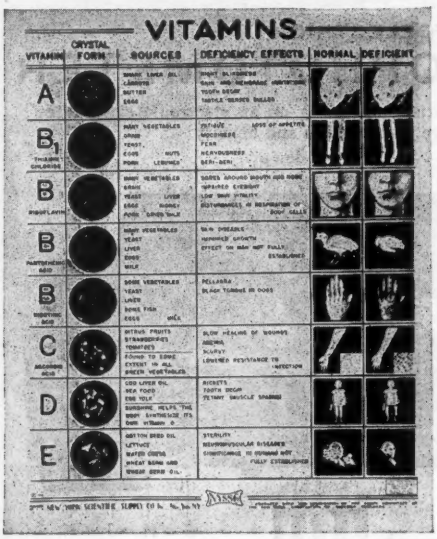

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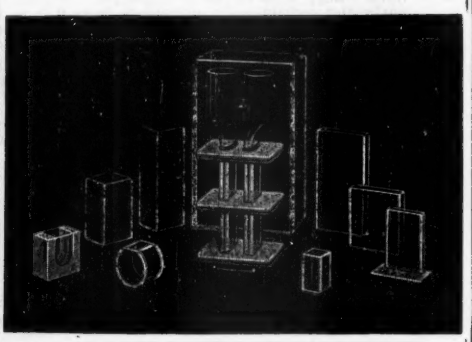

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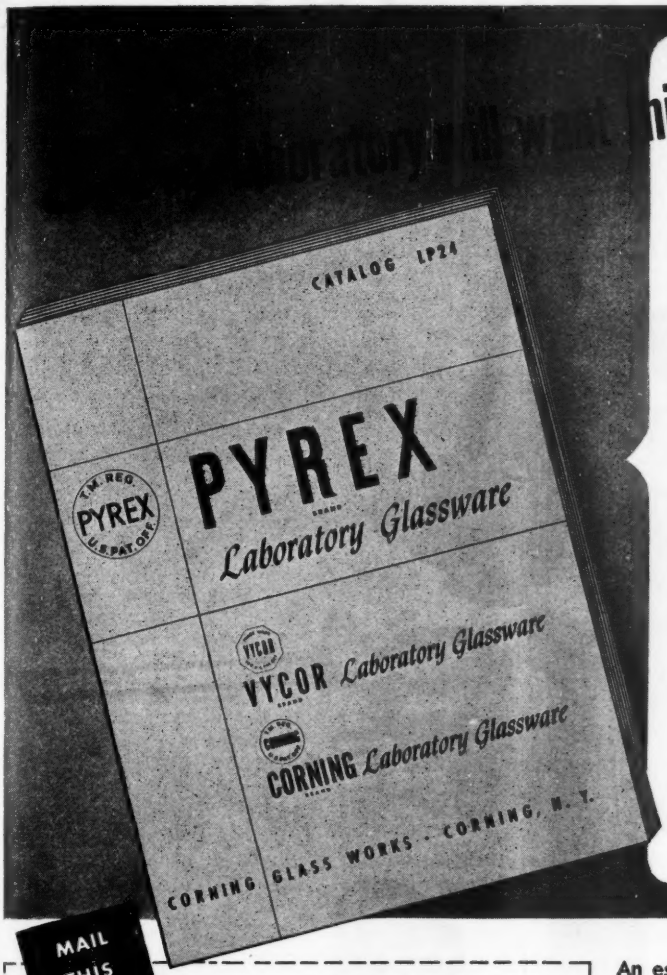

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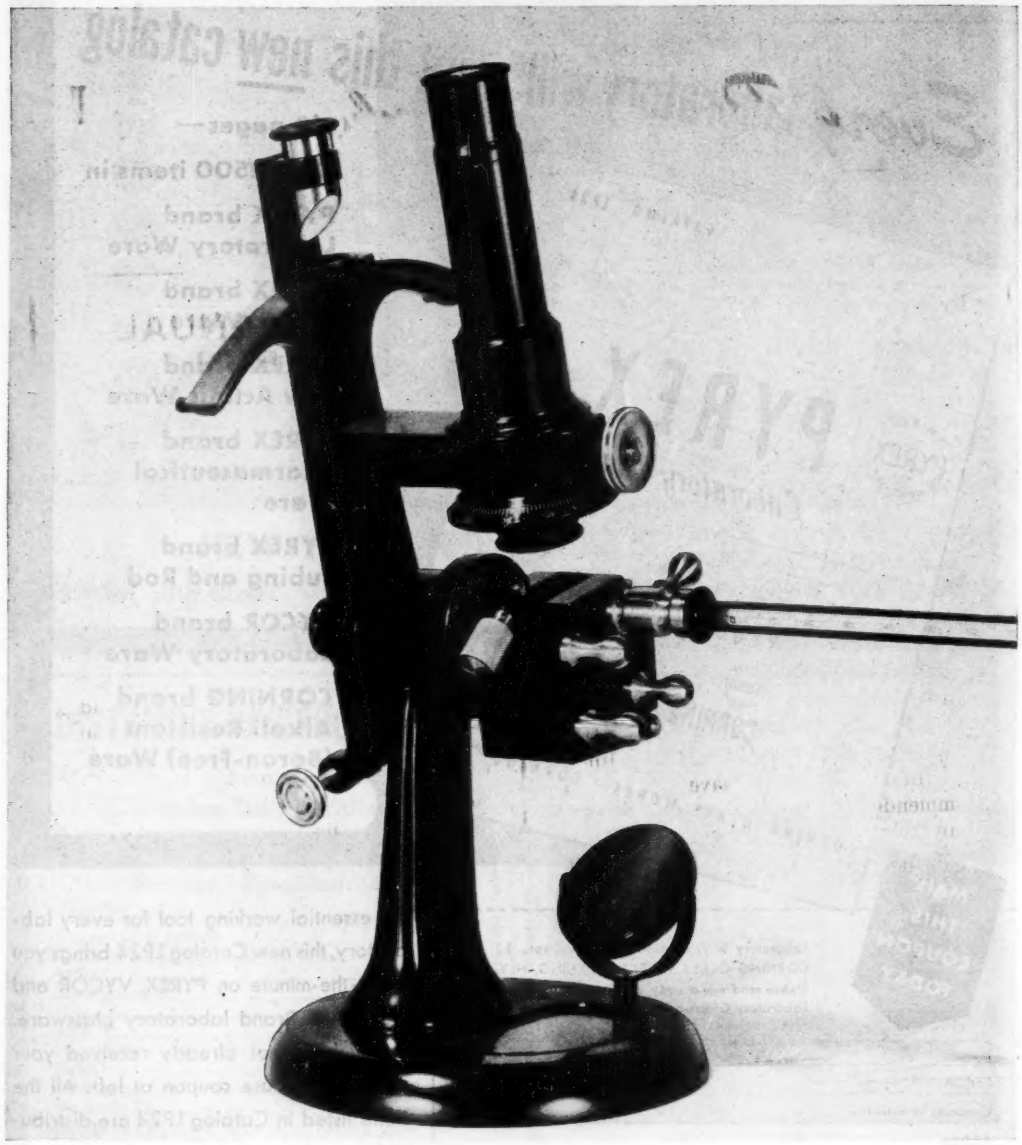

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ON THE TEACHING OF MATHEMATICS[1]

By Dr. F. D. MURNAGHAN
THE JOHNS HOPKINS UNIVERSITY

THE principal obligation incurred by a vice-president of the American Association for the Advancement of Science upon his election to office is the preparation, and deliverance before the section of which he is chairman, of an address. In discharging this obligation I wish to speak on a subject which I regard as of fundamental importance, namely, the teaching of mathematics. By this I mean not merely the provision of information about mathematical methods and results but also the development of an interest in, and understanding of, the spirit of mathematics. For I take it as evident that no teaching can be successful which attempts to skim off the products of mathematical fermentation and ignores the process of fermentation itself.

It is unnecessary for me to dwell on the fact that the demands of war have focussed a strong search-light upon the mathematical capabilities of graduates of our high schools and colleges, nor to call to your attention the fact that the disclosures are disquieting. All of us who teach know that it is possible for a young man to spend twelve years in school and yet not know with that assurance, which comes only from a thorough understanding, how to add fractions. When we meet a young man in college who calculates thus:

$$\frac{1}{2}+\frac{1}{3}=\frac{2}{5}$$

it is not enough to chide him for his stupidity. No, the fault lies in the manner of his teaching. We expect our students to add $\frac{1}{2}$ to $\frac{1}{3}$ and obtain a result without knowing what $\frac{1}{2}$ or $\frac{1}{3}$ is. I visualize you as objecting thus: "Why, this is absurd; every young student is told that $\frac{1}{2}$ is one half, *i.e.*, one divided by

[1] Retiring vice-presidential address before Section A of the American Association for the Advancement of Science, Cleveland, September 12, 1944.

2." The obvious rejoinder to this is: if one can be divided by 2, why not tell the answer? Why write both the dividend (1) and the divisor (2), when giving the "answer" $\frac{1}{2}$, save for the fact that the division is impossible? The simple truth is that fractions were introduced just because the division of one whole number by another is not always, although it is sometimes, possible. On sober thought the wonder is that so many people succeed in learning how to add fractions correctly without ever knowing clearly what a fraction is; not that so many people fail to learn how to add fractions. This is, then, the burden of my address; I believe that our failure, in so far as we have failed, lies in our hurry to secure results without understanding the processes involved. I believe further that our haste is vain; that the time necessary to gain the understanding is more than made up for by the increased rapidity with which the results can be mastered after the understanding has been gained. I believe also that those who fail to gain, even when properly taught, the understanding for which we should strive become at least as technically proficient as those who are trained to perform in a routine manner calculations whose significance they can not understand.

Since criticism is valueless if it does not prove itself constructive, I shall indicate briefly how I think mathematics should be taught. Starting, as every one does, with the counting numbers, I would emphasize their two essential features, namely, the existence of a leader 1 and the existence of a follower for each number, and I would point out that these imply the sensational and somewhat disquieting fact that whilst there is a leader or beginner, there is no ender. I would train my students to distinguish between definitions and theorems. For instance, if I ask what is the number twenty, I do not want to be told that it is twice ten; for I do not know (at the beginning stage) what twice means, and I may just as well ask what ten is as what twenty is. The answer I expect is: Twenty is the follower of nineteen. I see at once that a difficulty confronts me; this answer is completely satisfactory if I am lucky enough to know already what nineteen means, but if I do not know this, it is of no use to me. But a door opens! I can now push back to the leader. Nineteen is the follower of eighteen; eighteen is the follower of seventeen and so back to one. But what is one? Do not spoil it all by a false sophistication and say that one is the follower of zero! No, we must be honest; one is simply the beginner or leader of the counting numbers. Being a leader he does not follow any one.

The stage is now set for the process of addition and the learning of the addition table. How does one know that "two and two is four"? Many of my friends and students regard this as a trick question; the statement being so self-evident as not to permit demonstration. I then ask what does "two and two" mean, and, amazing as you may think this to be, I seldom receive a clear-cut answer. Of course everything rests on the sturdy shoulders of the leader; "and one" means merely "the follower." "And two" means "the follower of the follower" and so on. Thus two and two is the follower of the follower of two, *i.e.*, the follower of three, *i.e.*, four. What is meant by nine and seven, *i.e.*, $9+7$? and what is meant by seven and nine, *i.e.*, $7+9$? Are these by definition the same? These are the natural, simple questions which our present generation of students is unable to answer. Of course $9+7$ is the follower of $9+6$, whilst $7+9$ is the follower of $7+8$, and the fact that $9+7=7+9$ is a consequence of the, by no means evident, fact that $9+6=7+8$. It is clear that in order to really find out that $9+7=16$, we must push back to $9+1$ which is, by definition, 10. Even the youngest beginner should sense, at least vaguely, the universality behind the result $9+7=7+9$, which universality is indicated by the algebraic stenography: $a+b=b+a$.

Now, and only now, are we ready to explain multiplication. What is meant by two times two? Is it the same as two and two? If so, why is three times three not the same as three and three? Here again, we must turn to the leader who now, in contrast to his behavior in addition where he changes everything ($a+1$ being never the same as a), is very polite: 1 times a (*i.e.*, a multiplied by 1 which we denote by $a\times 1$) is always the same as a. What is 4×3? It is $(4\times 2)+4$. And what is (4×2)? It is $(4\times 1)+4$, *i.e.*, $4+4$, *i.e.*, 8. Thus multiplication is defined in terms of addition. $2\times 2=2+2$ merely because $(2\times 2)=(2\times 1)+2$, and, due to the politeness of the leader, $2\times 1=2$. Is it, then, remarkable that $6\times 9=9\times 6$, or is this an obvious consequence of the definition? Well, $6\times 9=(6\times 8)+6$, whilst $9\times 6=(9\times 5)+9$, and it is quite remarkable that $48+6=45+9$. Nevertheless, the beginner should be told that this remarkable fact may be proved, and the universality of the law: $a\times b=b\times a$ should be pointed out. But our intelligence must protest against such a demonstration as the following: to prove that $6\times 9=9\times 6$, construct a rectangle of sides 6 and 9. Then the area of the rectangle is at once 6×9 and 9×6; hence $6\times 9=9\times 6$. If you tell me such things I have to ask you what you mean by the area of a rectangle. If you answer that you mean the product of the two sides, I have to ask you which product? If you assure me that it makes no difference and advise me not to worry, I may trust you, but we are not discussing mathematics. Faith is a very important thing, but it can not be taught.

Every schoolboy learns the multiplication table as far as 10 times 10. No single item in his later study of mathematics is as difficult or makes as many demands upon his memory. At this stage in his study, interest in mathematics may be aroused by the mere statement of the following rule which seems to be novel to most of my friends: to multiply two numbers which lie between 5 and 10, add their excesses over 5 to obtain the tens figure and multiply their shortages under 10 to obtain the units figure. Thus $7 \times 9 = 63$, since $2 + 4 = 6$ and $3 \times 1 = 3$.

We have now reached a critical point in the teaching of mathematics. A high percentage of educated persons report somewhat as follows: "I was always rather good at arithmetic and enjoyed it; but I never did understand those negative numbers and why one has to be careful in working with zero. These things floored me and I have had ever since an inferiority complex with respect to mathematics!" To understand what negative numbers and zero are, one must change entirely one's attitude towards number. It is no longer sufficient to count; we must count from somewhere. If we visualize the numbers as men in a parade we are no longer concerned with where in the parade is a particular friend Tom of ours. We have two friends, Tom and Dick, and what concerns us is their relative position: where is Dick compared with Tom? Does he come earlier or later and how far apart are our two friends? The thing we call a number now is a pair (Tom and Dick) of counting numbers, *e.g.*, 4 and 7, where it is of the highest importance which is Tom and which is Dick. In other words, we concern ourselves with an ordered pair, *e.g.*, (4, 7) of counting numbers, and we call this pair *a* number (*not* two numbers). To justify, however, the name number, we must learn how to add and how to multiply these ordered pairs of counting numbers. To bring clearly into focus the fact that what really concerns us is the relative position of Tom and Dick, we recognize that the relative position of Tom and Dick is the same as the relative position of the follower of Tom and the follower of Dick. Thus, for instance, we have to agree that (4,7) is the same as (5,8) and this again is the same as (6,9) and so on. Thus the *same* number may have *many* appearances or costumes. How can we penetrate this disguise? The answer is very simple: (4,7) is the same as (5,8) because $4 + 8 = 7 + 5$; and, in general, (a,b) is the *same* as (c,d) when, and only when, $a + d = b + c$. This being agreed on, a serious political situation confronts us. On one side we have the early settlers, the honest-to-goodness numbers, the counting numbers which constitute a kind of aristocracy amongst the new comers—these ordered pairs of counting numbers which have so many costumes which they change at will and without notice. This class distinction would be fatal to any convenient mathematical theory, and we abolish it. We decree that the leader, 1, of the aristocrats must dress up in any one of the costumes (1, 2), or (2,3) or (3,4) and so on. His follower 2 must wear one of the costumes (1,3), (2,4), . . . , (6,8) and so on. In general the counting number n must dress up as $(1, n+1)$ or $(2, n+2)$ and so on. This decree is absolute; if any one of the counting numbers refuses to wear the costume assigned him, we do not admit him to the *new* republic of numbers; he must continue to live in the country or republic of counting numbers. If he wishes to do business with the republic of ordered pairs, he must deal through his representative who must wear the prescribed costume.

Having now agreed upon the appearance of, or costume worn by, our numbers, we must turn to the really important problem of writing their constitution; in other words, we must lay down the laws of addition and multiplication under which they must live. You must understand clearly that one can not prove these laws; they merely express what we regard as right and proper. Mathematics being a very pragmatic science, the words right and proper are merely synonyms for the word convenient; and of all revolutions the most convenient one is a bloodless one. We assure our aristocrats, the counting numbers, that, when they assume the toga of citizenship in the republic of "ordered pairs," they will not have to change in even the slightest manner their accustomed mode of life. The laws of addition and multiplication of ordered pairs are so framed that "and one" will still be the (dressed-up) follower; and, further, the leader 1 will still be polite in multiplication. What are these laws of addition and multiplication? The law of addition is extraordinarily simple; merely add the first parts of each pair and the second parts of each pair, separately, to obtain, respectively, the first and second parts of the sum:

$$(a,b) + (c,d) = (a+c, b+d).$$

To check that $3 + 4$ is still 7, we write 3 as (1,4) and 4 as (1,5) and find that $(1,4) + (1,5) = (2,9) = (1,8)$ (since $2 + 8 = 9 + 1$) and (1,8) is merely one of the costumes worn by 7. Even the beginner may grasp the remarkable fact that this law of addition depends in no way on the costumes worn by the individual terms. The law of multiplication is much more complicated:

$$(a,b) \times (c,d) = (ad + bc, bd + ac).$$

In words: use cross multiplication (*i.e.*, a with d, and b with c) and addition for the first part, and *straight* multiplication (*i.e.*, a with c and b with d) and addition for the second part. This complicated rule of multiplication may be remembered as follows: first

multiply each number of the first pair by the second number of the second pair obtaining (ad,bd); then multiply each number of the first pair by the first number of the second pair and reverse the order obtaining (bc, ac); finally add the two pairs (ad, bd) and (bc, ac) to obtain the product $(ad+bc, bd+ac)$. To verify the politeness of 1 when wearing, for example, the costume (3, 4), let us multiply 6, wearing the costume (4, 10), by (3, 4); we obtain

$$(4,10) \times (3,4) = (16+30, 12+40) = (46,52)$$

which is one of the costumes of 6.

The whole point of this bloodless revolution is that the franchise is extended to a great body of new citizens; if it merely meant that the counting numbers were to dress up and carry on their ordinary mode of life, it would be play acting and unworthy of serious attention. Amongst the new citizens is a very remarkable one whose costume is distinguished by the fact that both of its parts are the same; for instance $(1,1),(2,2), \ldots, (9,9), \ldots$ are several of these costumes. The amazing characteristic of this man is his dual personality. He is (like the leader 1 of the counting numbers when multiplication is being performed) utterly polite when addition is being performed:

$$(a,b) + (1,1) = (a+1,\ b+1) = (a,b)$$

(simply because $(a+1)+b = (b+1)+a$). To make up for this politeness (almost a lack of interest) when addition is being performed, he is utterly ferocious (a bandit really), when multiplication is being performed: the product of any number whatsoever by (1,1) is (1,1). For example,

$$(8,15) \times (1,1) = (8+15,\ 8+15) = (23,\ 23) = (1,1).$$

This bandit-like behavior is so characteristic that other numbers fight shy of (1,1) in the following sense: if we know that the product of any two numbers is (1,1), we may rest assured that one of these two numbers was (1,1) itself. This is the fundamental principle underlying the solution of all algebraic equations. We simply maneuver some statement, or combination of statements, concerning numbers into the form of statement that the product of two numbers (one or both usually unknown) is (1,1). This solves, at least partially, the mystery: one or other (which one we do not know) of the two unknown numbers is (1,1).

This new number is the number zero. What are the negative numbers? The negative of a number is the number obtained by interchanging its two parts. Thus -5 (the negative of 5) has (6,1) as one of its costumes simply because (1,6) is one of the costumes of 5. It follows at once that the negative of zero is zero, and that this is a characteristic property of zero; no number other than zero is its own negative. Furthermore, the sum of any number and its negative is zero; for instance $(4,9) + (9,4) = (13,13) = (1,1)$. It is easy to see that the negative of any number is the product of that number by $(2,1) = -1$. If we imagine each ordered pair as realized by a coin with one of the two parts of the number on each of its sides, we obtain the negative of a number by turning the coin over. The fact that a double turn over is as if the coin were not turned over at all finds its expression in the mysterious Rule of Signs:

$$- \times - = +.$$

It should be now clear that such a question as: Can you have zero apples? or -5 apples? merely betrays a complete lack of understanding of what zero or -5 is. Neither of these is a counting number and so one can not count with them; I can not have zero apples, but I can have the same number of apples as you; similarly, I can not have -5 apples, but you can have five more apples than I have. The numbers which express my standing relative to yours with respect to the possession of apples, are, respectively, zero and -5.

We have seen that we have been able to achieve a bloodless revolution, but it has not been an inexpensive one. As part of the taxes which must be paid by us, and by posterity forever, for this revolution, is the fact that our numbers no longer have a leader; the old leader (1,2) is now the follower of (1,1) because $(1,1) + (1,2) = (1,2)$. The polite (1,1) is the follower of (2,1) because $(2,1) + (1,2) = (3,3) = (1,1)$ and so on. Each of our numbers has a follower, but there is no beginner. To those of us who are conservatively minded and who miss the leader, we can only make the consoling remark that even in the good old days, although our numbers (the counting numbers) had a beginner, they had no ender. Now the matter is at least more symmetrical; every number has a follower, but there is no beginning and no end.

Once it is clearly understood that all numbers are ordered pairs of counting numbers, it is no longer dangerous to use a condensed notation in which 5, for instance, denotes (1,6), whilst -4 denotes (5,1) and 0 denotes (1,1). The advantage of this notation is that its use renders it unnecessary to remember the complicated rule by which ordered pairs are multiplied. The ordinary multiplication table for counting numbers, together with the rule of signs and the fact that, if one factor of a product is zero, so also is the product, are all we need to know. But no real understanding of negative numbers can be gained if one thinks that the numbers we are dealing with, or at least those of them which are neither negative nor zero, are counting numbers. It is the failure of our present teaching methods to emphasize this fact that

lies at the root of all the difficulty with negative numbers and zero. A further advantage which may be claimed for the teaching of negative numbers as ordered pairs of counting numbers is that the student is prepared for the concept of a vector which is so fundamental in physics and engineering. A vector simply carries one (as the name implies) from one point to another; the negative number -5 carries one from the counting number 6 to the counting number 1 whilst the positive number 5 carries one from the counting number 1 to the counting number 6.

Now what about the fractions? So that there may not be any misunderstanding, we shall refer to any one of our ordered pairs of counting numbers as an integer; thus $5=(1,6)$ is an integer, as are also $-8=(9,1)$ and $0=(1,1)$. A fraction is an ordered pair of integers which we write thus: $\frac{a}{b}$. Thus four counting numbers in all are required to define a fraction, two for the numerator a and two for the denominator b. We admit our integers (which now, in this new revolution, play the role of aristocrats) into the republic of fractions, by decreeing that each integer must appear as a fraction whose denominator is the integer 1. Thus when we write the symbol 5 we mean the fraction $\frac{5}{1}$; this is no longer either the counting number 5 or the integer $5=(1,6)$. Just as each integer has many costumes (each a pair of counting numbers), so each fraction has many costumes (each a pair of integers). We penetrate this disguise by the rule that $\frac{a}{b}=\frac{c}{d}$ when, and only when, $ad=bc$. For example $\frac{10}{2}$, $\frac{-15}{-3}$ are appropriate costumes for the number 5.

In order to justify our calling the fraction $\frac{a}{b}$ a number we must learn how to add and how to multiply fractions. In framing these laws of addition and multiplication, we take care that they do not disturb the laws of addition and multiplication of integers; *i.e.*, we arrange that

$$\frac{a}{1}+\frac{b}{1}=\frac{a+b}{1};\quad \frac{a}{1}\times\frac{b}{1}=\frac{a\times b}{1}.$$

As far as multiplication is concerned, this is very easily done; we adopt as our rule of multiplication the following:

$$\frac{a}{b}\times\frac{c}{d}=\frac{a\times c}{b\times d}.$$

In other words, we multiply the numerators of our separate fractions to obtain the numerator of our product fraction, and we multiply the denominators of our separate fractions to obtain the denominator of our product fraction.

It requires more skill to devise a rule of addition of fractions which will leave undisturbed the manner in which integers have been added. This rule is symbolized thus:

$$\frac{a}{b}+\frac{c}{d}=\frac{ad+bc}{bd}.$$

The real trouble for the beginner is the lack of symmetry with respect to the numerator and denominator; the denominator of the sum is the product of the two denominators, whilst to obtain the numerator we cross multiply and add, *i.e.*, we multiply the numerator of either fraction by the denominator of the other and add the two products thus obtained. What, then, is the sum of $\frac{1}{2}$ and $\frac{1}{2}$? It is $\frac{2+2}{4}$, *i.e.*, $\frac{4}{4}$ or 1. I feel strongly that the accepted mode of teaching the addition of fractions with its emphasis on "the least common denominator" is responsible for most of our troubles. Even very young beginners quickly learn (and seem to enjoy) the simple rule: cross multiply and add for the numerator; multiply for the denominator. Once they learn this rule they never seem to make the mistake indicated by $\frac{1}{2}+\frac{1}{3}=\frac{2}{5}$, but, rather, say correctly $\frac{1}{2}+\frac{1}{3}=\frac{5}{6}$. If you object that the rule of addition does not give the sum "in its lowest terms" as often as does the method involving the least common denominator, I reply that this is a very small price to pay for the increase in accuracy gained. According to the rule of the least common denominator $\frac{1}{2}+\frac{1}{4}$ is $\frac{3}{4}$, whilst according to the "cross multiply and add" rule it comes out $\frac{6}{8}$, which is merely $\frac{3}{4}$ wearing another costume. But if the "cross multiply and add" rule should increase the accuracy of performance by 10 per cent. (which I believe to be a conservative estimate), it is well worth the trouble involved in noting that $\frac{3}{4}$ is a "simpler" cosume than $\frac{6}{8}$ for the desired sum. What is much more serious is the fact that our students obtain under the present methods of instruction the impression that they can prove how fractions should be added.

The difference in the behavior of the integers and the fractions with respect to the two operations of addition and multiplication should be emphasized. The addition of integers is very simple:

$$(a,b)+(c,d)=(a+c,\ b+d),$$

whilst the multiplication of integers is complicated. On the other hand, the multiplication of fractions is very simple:

$$\frac{a}{b}\times\frac{c}{d}=\frac{a\times c}{b\times d}$$

whilst the addition of fractions is complicated. We may say that integers are made for addition; for them it is a natural operation which they perform without having to be taught, whilst multiplication is a skilled operation which they must learn how to perform. In contrast with this, fractions are made for multiplication, whilst addition is for them a skilled operation.

We have seen that there is a Rule of Three, namely $ad=bc$, by which we can test whether two fractions $\frac{a}{b}$ and $\frac{c}{d}$ are the same or not (just as there is a Rule of Three, namely, $a+d=b+c$ by which we can tell whether two integers (a,b) and (c,d) are the same or not). We can use these Rules of Three to arrange our integers and fractions in order; our guiding principle being always that we leave undisturbed the order which was such a prominent characteristic of the counting numbers. We say that (c,d) follows, or is greater than, (a,b) if $a+d$ follows $b+c$. For example 0 (*i.e.*, (1,1)) is greater than every negative number; this "largeness" of the number zero should be emphasized (to counteract the impression that when you "have zero" you have "simply nothing at all," everything having vanished into thin air). In ordering the fractions we have to be a little more careful; we first note that $\frac{a}{b}$ and $\frac{-a}{-b}$ are merely different costumes for the same fraction and so we may, if we find it convenient, decree that the denominator of a fraction shall never be negative. Suppose we do this; then we say that $\frac{c}{d}$ follows, or is greater than $\frac{a}{b}$, if cb follows, or is greater than ad. But then it becomes clear that we must outlaw all fractions whose denominator is zero in view of the bandit-like behavior of zero in multiplication. The Rule of Three itself outlaws the fraction whose numerator and denominator are both zero. For it tells us that every fraction $\frac{a}{b}$ is the same as $\frac{0}{0}$ because $a\times 0=b\times 0$. If we wish to preserve the axiom of equality: "Things which are equal to the same thing are equal to each other," we would have to grant the absurdity that all fractions are equal if we admitted the fraction $\frac{0}{0}$. We outlaw then $\frac{0}{0}$. This should be emphasized; under present teaching methods too high a percentage of college students *cancel* the zeroes and say that $\frac{0}{0}=1$.

What about the fractions whose denominators are zero but whose numerators are different from zero? These are all, by the Rule of Three, equal, but no one of them is equal to a fraction whose denominator is different from zero. They must *all* be outlawed. Consider, for example $\frac{10}{0}$; this fraction follows $\frac{10}{1}$ because $10\times 1=10$ follows $0\times 10=0$. On the other hand $\frac{-10}{0}$ $\left(\text{which equals } \frac{10}{0}\right)$ is followed by $\frac{10}{1}$ because $10\times 0=0$ follows $1\times -10=-10$. Thus if we admitted $\frac{10}{0}$ into our community of fractions we would have to admit that $\frac{10}{1}$ is at once greater than and less than $\frac{10}{0}$. Why is it that the one thing that my students are quite certain about concerning fractions is that the value of $\frac{10}{0}$ is infinity? When I ask them just what they mean by the word infinity, they are usually wise enough to remain silent.

How costly has our second bloodless revolution been? In our first revolution, in which we turned away from the counting numbers towards the integers, we sacrificed the leader but we still kept the concept of a parade (without beginning or end). Now, in turning away from the integers towards the fractions, we have sacrificed the last remaining characteristic of the counting numbers, namely, the concept of the follower. If you mention any two fractions, say $\frac{1}{2}$ and $\frac{1}{3}$, I know which of these follows the other; $\frac{1}{2}$ follows $\frac{1}{3}$ because 1×3 follows 2×1. But I can average the two fractions; *i.e.*, I can take their sum $\frac{5}{6}$ and multiply it by $\frac{1}{2}$ obtaining $\frac{5}{12}$. This average follows $\frac{1}{3}$ and is in turn followed by $\frac{1}{2}$. Thus between any two fractions there lies a third, namely their average; no fraction has an immediate follower.

Once the similarity between fractions and integers is thoroughly understood, a natural question arises. What corresponds in the theory of fractions to the negative of a number in the theory of integers? Adopting again our visualization by means of coins, we may say that the numerator of our fraction is stamped on the upper, and the denominator on the lower, side of the coin. Then all coins save one may be turned over; the one which is nailed down being that one which has zero on its upper side. We obtain, in this way, from every fraction save zero a new fraction which we term its inverse or reciprocal. For instance, the inverse of $\frac{3}{4}$ is $\frac{4}{3}$. Just as there is one, and only one, integer (namely, zero) which is the same

as its negative, there is one, and only one fraction (namely, 1) which is the same as its inverse. Just as the sum of an integer and its negative is zero, so also the product of a fraction by its inverse is 1. This deep-lying parallelism finds its true expression in the theory of logarithms, about which we shall say nothing further here.

In this outline of the things which I think are essential in the teaching of elementary arithmetic and algebra, I have only mentioned the two basic operations of addition and multiplication. Why have I ignored subtraction and division? Well, if I had my way, I should outlaw these terms just as we have had to outlaw fractions whose denominator is zero. It is a delusion to think that we can subtract in the republic of counting numbers, or divide in the republic of integers. For this delusion creates class distinctions which are opposed to the very idea of a republic; we can subtract 3 from 8, but we can not subtract 8 from 3; and we can divide 4 by 2 but we can not divide 3 by 2. Once this is clearly realized, the very reason for the concepts of subtraction and division evaporate. If we wish to subtract we change the sign and *add;* in other words, we never subtract, we always add. If we wish to divide (a thing which can only be done in a satisfactory manner under the constitution of the republic of fractions) we invert and multiply; in other words, we never divide, we always multiply. I feel that this is more than an aesthetic question about which argument is profitless. When I ask my students to solve the equation $2x = 8$ I never have, in a quarter century's experience in teaching, received a wrong answer. But when I ask how the correct answer $x = 4$ is obtained, I am told, without a single variation in the answer, that the 4 is obtained by dividing 8 by 2. When I ask what this means, I usually fail to receive anything more illuminating than a look of indignation. I hope sometimes to be told that the four was obtained by multiplying both sides of the equation $2x = 8$ by $\frac{1}{2}$; and my conviction that a better era of teaching has arrived will be complete if my student adds that it is a very comforting fact about multiplication that $\frac{1}{2} \times 2x = \left(\frac{1}{2} \times 2\right) x = 1 \times x = x$. He will thus show me that he has not only heard about, but has to some extent realized the importance of, the associative law of multiplication. When I ask this future student of mine what $\frac{1}{2}$ is, he will not say one divided by 2; he will say that it is the inverse of $\frac{2}{1}$ or 2. And in explaining what he means by $\frac{3}{2}$ he will be too well taught to imagine that by some magic he has learnt how to divide 3 by 2. He will say simply that $\frac{3}{2}$ is the product of $3 = \frac{3}{1}$ by the inverse $\frac{1}{2}$ of $2 = \frac{2}{1}$.

So far we have discussed only those matters which belong to the elementary schools and have left little time for the topics taught in the high schools and colleges; for this we make no apology for "as the twig is bent so grows the tree." In the high school the student should learn that further peaceful revolutions are necessary before he understands what is meant by an irrational number such as $\sqrt{2}$ and by complex numbers. For these latter numbers (which are so important in such practical applications of mathematics as radio transmission) the revolution is exactly of the same type as those which introduced the integers and the fractions. Let us devoutly hope that no longer will a teacher, after telling a student that the square of a number is always positive, insist that he manipulate the square root of minus one. It is little comfort to a properly rebellious student to say that he may salve his conscience by terming this mysterious symbol an imaginary. A good teacher will tell his students, when they are studying algebra, that there is not merely one algebra but that many algebras exist. It is a matter of national pride that America is now the foremost contributor to the theory of Modern Algebra, that wonderful creation of the human mind which has proved so fundamental for the most recent advances in physics.

In closing this address, I think that I should try to forestall the following criticism: Here is a college or university professor engaged in the age-old pastime of passing on the blame. All he can find to do is to criticize the teaching in the more elementary schools. I can assure you that I am not very happy about the way mathematics is taught in our colleges. In a long experience, I have had many graduate students, all of whom had studied calculus. Believe it or not, most of them are surprised when I tell them that in studying calculus they have been learning how to calculate; and that the adjective differential in the term differential calculus has something to do with the word difference. To drop to the freshman level, I find very few amongst the multitudes studying trigonometry, *i.e.,* the science of measurement of angles, who know what an angle is. The few who do know in a vague way that it is the length of a circular arc have never been told that the length of a circular arc is a difficult concept whose mastery marks an important stage in the development of an understanding of mathematics.

The net result is that a large part of our teaching of mathematics in college has degenerated into a mechanical formalism under which the best students

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can differentiate and integrate the most elaborate expressions, frequently without a clear understanding as to what is going on. What does it mean to say that a function is differentiable or that it is integrable? When I ask this question, I want a clear-cut answer in simple terms, not the parrot-like repetition of some definition in a text book. There is far too much talk in the teaching of mathematics. If I were an architect designing a mathematics class room, I would have cut in large letters above the blackboard the motto:

Cut out the talk; what have you got?

To those of you who teach mathematics and who say to me that my program is too idealistic and that one simply can not teach mathematics properly, I must point the accusing finger. Study well your responsibility before you poison the wells. Do not, I urge you, be so pessimistic. It is as easy (really much easier) to teach mathematics correctly as to teach it incorrectly; and I can assure you that it is much more fun. As a born Irishman I am entitled to close the book for the day, before the evening is too far advanced, and looking up, say to my good companions: Let's have a little fun. *Beannacht leat;* God be with all here, may He bless the work and the fun.

CULTURAL INTERCHANGE BETWEEN THE SOVIET UNION AND THE UNITED STATES[1]

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THROUGHOUT many generations in which creative intellectual activity was the privilege only of the few in Russia, Russian scientists, authors and composers nevertheless produced works of the highest quality which have greatly enriched the culture of the entire world. Mendelejeff, Metchnikoff, Iwanowski, Winogradsky, Pavlov, among others, may be mentioned as examples of men whose contributions are basic to modern chemistry, agronomy and medicine.

In the Soviet Union education and pure scientific and technological training have become the privilege of the many and have been vigorously fostered by the government. A great development of mathematics and physics, agriculture, geography, geology, the biological and medical sciences and the technologies has resulted and has afforded the foundation without which Russia's magnificent achievements in the present war would never have been possible.

What the Soviet Union has actually achieved in pure science and technology within a single generation may be taken as a measure of how great her contribution to world culture and well-being may become under conditions of peace. Science can discover and develop the necessary means for material comfort and well-being; no well-informed person seriously doubts that, I believe. There are, however, far subtler and more complex problems for the solution of which scientific method and scientifically minded men must give their best efforts. For instance, living which brings satisfaction and creative possibilities to the individual and the group is by no means solely the result of material well-being, but of complex physiological and emotional adjustments producing inner harmony; the conditions of this inner harmony I sincerely believe are ultimately discoverable by scientific method. The complex conditions necessary for economic and social adjustment and well-being, I believe, too, are ultimately discoverable through rational methods, and are in considerable measure capable of achievement, in a world of men of good-will.

Any scientist knows that such complex problems as these require the joint effort of many people, with many divergent backgrounds, working from many different angles of approach. From the point of view of the social or natural scientist, therefore, diversity of experience and of social and economic organization is to be welcomed and valued. We need the common efforts and friendly rivalry of Soviet and American, of French, British and Chinese and every other kind of social and natural scientist if a better and more harmonious world is to evolve.

May I repeat. To the scientist striving for understanding and peaceful evolution, diversity is welcomed. Areas of difference between people of different nations should be precisely and rigorously defined in order that apprehension should be confined within the limits thus prescribed, leaving the whole world of ideas outside these limits as the common heritage of mankind. It is when the fear arises that revolution or conquest may impose an alien order by coercion that suspicion and ill-will appear. Let every citizen of our two great countries resolve that change shall henceforth be by cooperative, peaceful evolution and never by such brutal conquest as our common enemies have attempted.

I am asked to speak concretely about the cooperation that now exists between American and Soviet scientists and the means by which this cooperation could be made more fruitful in the future. Cooperation at present is terribly handicapped by the exigencies of

[1] Address before the dinner of the American Russian Institute, New York, October 20, 1944.

the war. What we need first, of course, is to know what Soviet scientists are doing and to have them know what we are doing. An important beginning has been made by the founding in October, 1943, of *American Review of Soviet Medicine*. Various commissions of scientists sent from Britain, Canada and the United States to Russia and by the Soviet Union to these countries have been helpful. But these measures are really only a meager beginning. We must have the fullest practicable two-way diffusion of scientific journals and books and ultimately, of course, of students, research workers and exchange professors.

Ways should be found as soon as possible to set up means for the importation of complete files of scientific periodicals and books into both countries and covering the entire period of the war during which inter-communication has been interrupted. This interchange should of course continue indefinitely into the future.

Agencies already exist in this country for indexing and abstracting Russian scientific literature in several areas of science. *Biological Abstracts* and *Chemical Abstracts* are examples. These agencies at present are handicapped by the impossibility of obtaining current Russian journals. A plan is at present being explored by *Biological Abstracts* looking to establishment of a central agency to survey all current Russian periodical literature in the biological sciences, to translate the worth-while articles into English and to republish in English as perhaps quarterly journals. Such a plan would seem most worthy of support. Would not a similar central agency in Russia for the literature in English be worth establishing?

Plans should certainly be elaborated for the interchange after the war of students, investigators and teachers between Russia and America.

International scientific congresses before the war brought valuable interchange of scientists between all civilized countries. The need for these will increase as problems of health, social and economic well-being become increasingly common to all nations. Plans and means for realization of all these forms of cultural interchange should be elaborated as opportunity affords.

It is encouraging to learn that fifteen Isaac Newton scholarships for students in mathematics and physics departments in Soviet higher educational institutes were recently established by the People's Commissariat of Education. Would it not be a useful contribution to establish scholarships in American universities in honor of great Russian scientists and to be held by English-speaking Russian students?

The common efforts of the Soviet and American Unions and of the other United Nations are now achieving victory against a barbarism which threatened to overwhelm good-will among men, scientific truth and the common weal of all mankind. Our common efforts will be equally needed after the war to enrich the culture and lay the foundations for the well-being of a world that must be kept at peace.

OBITUARY

FRERE MARIE-VICTORIN

PROFESSOR MARIE-VICTORIN, eminent botanist, met his death on July 15, 1944, while returning with four companions in his automobile from a collecting trip to Black Lake, Megantic County, in the Eastern Townships of Quebec. The trip had been organized especially to find a rare fern (*Cheilanthes siliquosa*) which grows only on the serpentine hills of that region. While returning to Montreal, at 10:30 in the evening, a collision occurred on the wide boulevard leading to St. Hyacinthe. None of the party was severely injured, but about half an hour after the accident, Frère Marie-Victorin collapsed and died from heart failure. He was in his sixtieth year, and would have completed his twenty-five years of university teaching in 1945.

Interment took place in the cemetery of the Christian Brothers at Mont-de-la-Salle, Laval-des-Rapides, near Montreal.

Frère Marie-Victorin, whose ancestors hailed from Brittany, was born on April 3, 1885, at Kingsey Falls, a tiny village in the Eastern Townships of Quebec. His father was Cyrille Kirouac, and his mother Philomène Luneau. He was baptized under the names of Joseph-Louis-Conrad. His parents having thereafter established themselves in the city of Quebec, where his father became a prominent merchant, young Conrad attended the Christian Brothers' school at St. Sauveur, and afterwards the Commercial Academy, where he was graduated in 1901, first of his class. He then entered the Christian Brothers' novitiate of Mont-de-la-Salle in Montreal, at that time situated in Maisonneuve Park, which was later to become under his initiative the Montreal Botanical Garden.

After a short stay as teacher in St. Jerome College and St. Leo's Academy in Westmount, he was attached in 1904 to Longueuil College, where he taught until 1928, and where he resided until his death. In his early twenties, he was very ill with tuberculosis for many months, and had to spend this period in the Laurentians, resting and at long last recuperating, though he remained weak for the rest of his life. It

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was during this period of forced rest that he became deeply interested in the study of wild plants, on which he started publishing papers right after his cure, about 1907–1908. From that moment, he became a frequent contributor to various periodicals, such as the *Naturaliste Canadien,* the *Ottawa Naturalist,* the *Bryologist,* the *Revue Trimestrielle Canadienne,* etc. His first important work was the "Flore du Témiscouata," a 125-page memoir issued in 1916.

The newly reorganized Université de Montréal appointed Frère Marie-Victorin professor of botany in 1920. Soon thereafter he started publishing a series of contributions, which appeared without interruption till the present time, and numbers at present fifty-five issues, all the earlier ones and many recent ones from his own pen.

In 1929 he travelled for several months in Europe, in Africa and in western Asia. Right after his return to Montreal he started a campaign for the foundation of a botanical garden, and was so successful in this venture that in 1932 the Montreal Botanical Garden came into existence. It was considerably expanded in 1936–1939, the University Botanical Institute itself moving in 1939 into the new large building erected to house the administrative and technical departments of the garden.

The most important work published by Frère Marie-Victorin is his "Flore laurentienne," a big quarto volume of over nine hundred pages, on which he worked for several years with his colleague Frère Alexandre (who drew all the illustrations) and several other collaborators.

Among the numerous botanical expeditions organized by Frère Marie-Victorin, the most outstanding series is probably that of 1924–1928 on the north shore of the Gulf of St. Lawrence and Anticosti Island. On the eve of his death he was actively engaged in the writing of the final phase of his report on these expeditions, a very extensive memoir which will eventually be published under the title of "Recherches floristiques sur l'Anticosti-Minganie."

Frère Marie-Victorin was a member of many scientific societies: the Royal Society of Canada, the Linnean Society of London, the Société Botanique de France and many others. In recent years several Latin countries of the Antilles and South America—for instance, Haiti, Cuba, Colombia, Ecuador and others—elected him to their national academies or honored him in recognition of his work on the tropical flora.

In his last years, Frère Marie-Victorin, whose health was failing and who could hardly endure the severe Canadian winters, used to spend three or four months each year in some tropical country, chiefly Cuba. During these sojourns he travelled extensively from one end of the island to the other, the result of these trips being his "Itinéraires botaniques dans l'île de Cuba," two big volumes, each of four hundred pages, profusely illustrated with hundreds of photographs taken by himself.

Apart from his scientific writings, Frère Marie-Victorin leaves several literary works, the best known being his "Récits Laurentiens" and "Croquis Laurentiens." An English version of the "Récits" was published under the title of "The Chopping Bee," and a re-edition of the French text appeared in Belgium a few years before World War II.

Honored nationally and internationally for his original investigations and his great learning, he will long be remembered with pride as an eminent Canadian scholar and with affection as a man of sympathy and gentle kindliness. In particular his many friends at McGill University will recall his never-failing generosity and his charming courtesy.

The spirit of Frère Marie-Victorin will live in the hearts and minds of the pupils who have been stimulated by his teachings and inspired by his example, while for more tangible memorials there will remain his scholarly works and the Botanical Gardens of Montreal.

These gardens in their original conception, their present excellence, and their future promise, are a beautiful tribute to his imagination, his assiduous industry, and his love for the flora of his native land.

To his colleagues of the University of Montreal the Senate of McGill University extends its most sincere sympathy.

The senior author of this sketch most heartily endorses the sentiments expressed by his colleagues at McGill University. A long friendship and an extensive period of joint travel (from Capetown through the Levant to Prague, and later through much of Germany) would justify a further, more personal encomium which, however, could add only an expression of deep personal loss and sorrow.

FRANCIS E. LLOYD
JULES BRUNEL

ALBERT KINGSBURY

ALBERT KINGSBURY was born in Morris, Illinois, on December 23, 1862, the son of Lester Wayne Kingsbury, whose ancestors settled in Dedham, Massachusetts, in 1628, and of his wife, Eliza Emmeline Fosdick, twice descended from the Elder William Brewster. From his forbears Dr. Kingsbury inherited an iron will, calm speech and ways, and a depth of feeling for all associated with him in any capacity, which bound him to them with bonds of mutual respect and affection.

He attended college for one year after graduating from high school, then worked for three years in a machine shop in Cuyahoga Falls, Ohio. In 1884 he entered Ohio State University for two more years of study, then worked for another year. In 1887 he entered Cornell University from which he was gradu-

ated in 1889 with honors and the degree of M.E., with election to Sigma Xi.

The following year he was instructor in mechanical engineering and physics at New Hampshire College (now the University of New Hampshire), after which he served as engineer for one year with the H. B. Camp Company of Cuyahoga Falls. In 1891 he returned to New Hampshire College as professor of mechanical engineering, and head of his department, where he remained until 1899. He was then professor of applied mechanics at the Worcester Polytechnic Institute from 1899 to 1903. For seven years later he was with the Westinghouse Electric and Manufacturing Company as general mechanical engineer, becoming in 1910 consulting engineer for the same firm and for several other firms. He was the founder and president of the Kingsbury Machine Works, Frankford, Philadelphia, for the manufacture of the Kingsbury Thrust Bearing. His work with lubrication and friction, his many published papers and inventions are well known and need not be enumerated here.

He received the highest engineering and academic honors: in 1923 the Elliott Cresson Medal by the Franklin Institute of Philadelphia for his invention of the Kingsbury Thrust Bearing; in 1931 the John Scott Medal by the City of Philadelphia; in the same year the Gold Medal of the American Society of Mechanical Engineers for his papers on engineering subjects; and in 1942 the Mechanical Engineers' Fifty Year Award. The Worcester Polytechnic Institute conferred upon him in 1933 the honorary degree of doctor of engineering, and in 1935 the University of New Hampshire the degree of doctor of science.

Dr. Kingsbury was a fellow of the American Association for the Advancement of Science, honorary member of the American Society of Mechanical Engineers, associate member of the American Institute of Electrical Engineers and member of the Engineers' Club of New York.

His interests were not confined within the limits of his professions. He lived with even greater satisfaction a broader life in the world of arts, history and letters. In his younger days he played the flute and sang in the choir of an Episcopal church. He was a competent judge of painting, a competent botanist. As he grew older, he devoted much time to the study of foreign languages, which he read extensively for intellectual refreshment—Italian, French, Spanish, German, Danish and several others—and qualified as an expert in the interpretation of the esoteric Mallarmé. No wonder then that the all too common illiteracy of many educated people, both in his own and other professions, distressed him, and that the restricted limitations of their conversation bored him.

He was a strong man physically, as well as mentally. He had a keen sense of humor, a ready wit and quick repartee. His memory was phenomenal, so that he quoted freely by verse and paragraph with appropriate settings. In politics he was a strong Republican, in religion a Presbyterian. A devoted husband and father, he passed away at his summer home in Greenwich, Connecticut, on July 28, 1944—an irreparable loss to his family, his friends and humanity.

EDWIN B. DAVIS

RUTGERS UNIVERSITY

RECENT DEATHS

AIDA AGNES HEINE, associate professor of geology and geography at Smith College, senior member of the faculty, who has been associated with the department of geology for thirty-nine years, died on October 18 at the age of sixty-four years.

DR. BERAM D. SAKLATWALLA, consulting metallurgist, from 1919 to 1935 a senior-vice-president and research director of the Vanadium Corporation of America, was killed on November 4 in an airplane accident at Hanford, Calif. He was sixty-three years old.

DR. GEORGE WHITELEY COGGESHALL, director of research for the S. D. Warren Company, paper manufacturers, died on November 19 at the age of seventy-six years.

SIR ARTHUR STANLEY EDDINGTON, F.R.S., Plumian professor of astronomy and director of the observatory of the University of Cambridge, died on November 22 at the age of sixty-one years.

PROFESSOR JOSEPH HUBERT PRIESTLEY, since 1911 head of the department of botany of the University of Leeds, died on October 31 at the age of sixty-one years.

SCIENTIFIC EVENTS

THE AMERICAN ACADEMY OF TROPICAL MEDICINE

THE American Academy of Tropical Medicine held its eleventh annual meeting at St. Louis on November 15. At the dinner session, Dr. Malcolm H. Soule presided as toastmaster and Colonel E. B. Vedder, U.S.A. (retired), delivered the annual presidential address. It was entitled "The Present Status of Tropical Medicine and Some Future Problems." Captain E. G. Hankansson, M.C., U.S.N., director of the Naval Medical Research Institute at Bethesda, and Dr. Donald L. Augustine, associate professor in the department of comparative pathology and tropical medicine of the Harvard Medical School, were elected to

membership. The following officers were elected for the coming year:

President—Dr. Mark F. Boyd, Rockefeller Research Laboratories, Tallahassee, Florida.

Vice-president—Dr. George W. McCoy, professor of preventive medicine and public health, Louisiana State University Medical Center, New Orleans, La.

Secretary and Assistant Treasurer—Dr. Ernest Carroll Faust, Department of Tropical Medicine, Tulane University of Louisiana, New Orleans, La.

Treasurer—Colonel T. T. Mackie, MC, AUS, Office of the Surgeon-General, Washington, D. C.

Councilor for a five-year term: Dr. R. E. Dyer, director of the National Institute of Health, Bethesda, Md.

THE NATIONAL ACADEMY OF SCIENCES

THE annual meeting of the National Academy of Sciences was held at the National Museum, Washington, on November 15 and 16.

The session on Wednesday afternoon was devoted to science as related to the war. Dr. Wilmot H. Bradley, chief geologist of the U. S. Geological Survey, spoke on "Geology as an Implement of War"; Dr. Francis W. Reichelderfer, chief of the U. S. Weather Bureau, on "Meteorology and the War," and Dr. Zay Jeffries, technical director of the Lamp Department at Cleveland of the General Electric Company, on "Metallurgy and the War." Major General G. M. Barnes, chief of the Research and Development Service of the Office of the Chief of Ordnance, took as his subject "American Science and Industry in War."

In the program for Thursday, November 16, the following papers were presented:

"Pressure Breathing: Certain Aspects of Its Military and Therapeutic Significance," by Commander J. Murray Steele, assistant research executive, Naval Medical Research Institute.

"The Physiological Basis of Engineering Advances in Military Aviation," by Dr. Detlev W. Bronk, professor of biophysics, University of Pennsylvania.

"The Anatomy and Physiology of the Airplane Cockpit," by Dr. Eugene F. DuBois, professor of physiology and biophysics, Cornell University Medical College.

"The Synthesis of Vitamins in the Intestinal Tract," by Dr. C. A. Elvehjem, professor of biochemistry, University of Wisconsin.

"The Deterioration of Equipment and Materials in the Tropics," by Dr. W. G. Hutchinson, assistant professor of botany, University of Pennsylvania.

"The Story of Penicillin," by Dr. Chester S. Keefer, director, Evans Memorial Hospital, Boston.

"The Treatment of Shock": a. "Some Physiological Aspects of Shock," by Dr. C. N. H. Long, Sterling professor of physiological chemistry, Yale University; b. "Clinical Aspects of Shock," Dr. John S. Lockwood, associate professor of surgery, Yale University.

"Research—the Key to Military Preventive Medicine," by Brigadier-General James S. Simmons, chief, Preventive Medicine Service, Office of the Surgeon-General.

"Control of Typhus," by Brigadier-General S. Bayne-Jones, deputy chief, Preventive Medicine Service, Office of the Surgeon-General.

MEDALS AWARDED BY THE ROYAL SOCIETY

THE Royal Society, London, has awarded the following medals for 1944:

The Copley Medal to Sir Geoffrey Taylor in recognition of his many contributions to aerodynamics, hydrodynamics and the structure of metals, which have had a profound influence on the advance of physical science and its applications.

The Rumford Medal to Dr. H. R. Ricardo in recognition of his important contributions to research on the internal combustion engine, which have greatly influenced the development of the various types.

The Davy Medal to Sir Robert Robertson in recognition of his researches on explosives, analytical methods, the internal structure of the diamond and infra-red absorption spectra.

The Darwin Medal to Dr. I. Stanley Gardner in recognition of his work on coral reefs and on the organisms associated with such habitats.

The Hughes Medal to Professor G. I. Finch in recognition of his fundamental contributions to the study of the structure and properties of surfaces; and for his important work on the electrical ignition of gases.

AWARD OF THE WALTER REED MEDAL

THE Walter Reed Medal was presented to Brigadier-General James Stevens Simmons, U.S.A., chief of the Preventive Medicine Service, Office of the Surgeon General, U. S. Army, in recognition of meritorious achievement in tropical medicine, and for outstanding work in safeguarding the health of American troops, at the annual meeting of the American Society of Tropical Medicine at St. Louis, Missouri, on November 15.

The Walter Reed Medal was established by the society in 1934 to be awarded periodically in recognition of meritorious achievement in tropical medicine by an individual or an institution. The medal "cast in bronze" has been awarded on four previous occasions. In 1936, one medal was awarded posthumously to Major Walter Reed for his experimental work on yellow fever and another to the Rockefeller Foundation for its study and control of yellow fever. In 1939 the award was made to Dr. William B. Castle, of Harvard University, and in 1940 to Dr. Herbert Clark, of the Gorgas Memorial Laboratory in Panama. In 1942 two medals were awarded, one posthumously to Dr. Carlos J. Finlay for his work on yellow fever and the other to The United States of Brazil "for outstanding

work in the eradication of *Anopheles gambiae* in Brazil."

At this meeting General Simmons was chosen president-elect of the American Society of Tropical Medicine.

AWARD OF THE PERKIN MEDAL

THE Perkin Medal for 1944 of the American Section of the Society of Chemical Industry has been awarded to Dr. Elmer K. Bolton, of Wilmington, Del., chemical director of E. I. du Pont de Nemours and Company.

Presentation of the medal, conferred annually for outstanding achievement in industrial research, will be made on the evening of January 5, at a joint meeting, held at the Hotel Commodore, New York City, of the Society of Chemical Industry, the American Chemical Society, the American Institute of Chemical Engineers, the Electrochemical Society and the Société de Chimie Industrielle.

According to the citation, the medal is conferred on Dr. Bolton in recognition of

leadership in the synthesis of the first general purpose synthetic rubber to be developed either in this country or abroad, and for his direction of nylon research.

His undertaking in 1925 of a search for a practical synthetic rubber, in spite of previous repeated failures, emphasizes his vision and boldness as a research director. Through his persistent stimulation and guidance, this search culminated in the commercial manufacture of chloroprene synthetic rubber, commonly known as neoprene, which to-day is a key product in the national synthetic rubber program.

A broad program to explore the fundamentals of polymerization phenomena was undertaken by the chemical department of the du Pont Company in 1928 under the late Dr. Wallace H. Carothers. In the course of these studies synthetic polyamides were discovered, and under Dr. Bolton's direction the development of nylon as a new and revolutionary commercial textile fiber was brought to successful fruition.

Dr. Bolton is the thirty-ninth recipient of the Perkin Medal, which was founded in honor of Sir William Henry Perkin, whose experiments led to his discovery of aniline dyes and the foundation of the aniline dye industry. He joined the staff of the du Pont Company at the Wilmington Experiment Station in 1915. In 1916, he was placed in charge of a group of chemists to study the preparation of synthetic dyes, for which America was at that time largely dependent upon Germany. Dr. Bolton became director of the chemical section of the du Pont dyestuffs department in 1921, assistant chemical director of the du Pont Company in 1929, and chemical director in 1930.

SCIENTIFIC NOTES AND NEWS

THE doctorate of laws was conferred on Dr. Robert A. Millikan, chairman of the executive council of the California Institute of Technology, on November 20 on the occasion of the annual Achievement Day celebration of William Jewell College, at which he made the principal address.

THE degree of doctor of laws was conferred on Dr. Robert Chambers, of New York University, by Queens University, Kingston, Canada, his alma mater, at the October convocation of the university.

COLONEL LEONARD G. ROWNTREE, director of the Philadelphia Institute for Medical Research, chief of the medical division of the National Headquarters Selective Service System, has received the scroll of honor of the New York State Committee on Physical Fitness, in recognition of his "interest, understanding and efforts in behalf of the physical fitness of a nation at war and the welfare of the youth of the future."

THE Medal for the Advancement of Research of the American Society of Metals has been awarded to Robert Crooks Stanley, chairman and president of the International Nickel Company of Canada, in recognition of "pioneering leadership in the field of metals research." The Henry Marion Howe Medal for the best paper to appear in the *Transactions* of the society was presented at the annual dinner of the society to Earnshaw Cook, chief metallurgist; J. A. Fellows, assistant chief metallurgist, and R. A. Flinn, assistant metallurgist, all members of the staff of the metallurgical laboratory at Mahwah, N. J., of the American Brake Shoe Company. The paper described a quantitative study of the transformation reaction of steel from high to low temperatures in heat-treating practices.

AT the eighty-sixth commencement exercises on September 28 of the Long Island College of Medicine, the first alumni medal for distinguished service to American medicine was presented to Dr. Robert L. Dickinson, gynecologist, who graduated from the college in the class of 1882.

THE Captain Joseph H. Linnard Prize of the Society of Naval Architects and Marine Engineers was presented at the fifty-second annual banquet of the society to Professor C. Richard Soderberg, professor of mechanical engineering at the Massachusetts Institute of Technology, and to Ronald B. Smith, director of research and development of the Elliott Company, Jeannette, Pa., on November 17. The award was presented jointly for a paper entitled "The Gas Turbine as a Possible Marine Prime Mover," selected as

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the best technical paper contributed to the society during 1943.

THE Order of the Sun of Peru in the class of Knight Commander has been conferred by the President of Peru upon Dr. J. C. Geiger, director of public health of the City and County of San Francisco, clinical professor of epidemiology at the University of California.

DR. ANDREW C. IVY, Nathan Smith Davis professor of physiology at the Northwestern University Medical School, will deliver on December 5 the presidential address at the twenty-ninth annual meeting of the Institute of Medicine of Chicago. His address is entitled "Contributions to Survival on a Raft at Sea."

DR. W. H. COOLIDGE, head of the department of chemistry in Kenyon College, will serve during the winter term as visiting lecturer at Denison University; Dr. H. F. Stroheeker, of the department of biology, will conduct courses in anatomy at Wayne University.

WILLIAM J. BAUMGARTNER, professor of zoology at the University of Kansas, having reached the age limit, has retired after forty years of service. He plans to continue his research and editorial work at the university.

DR. JOSEPH D. KELLY, of the Manhattan Eye, Ear and Throat Hospital, has been appointed professor and chairman of the department of otorhinolaryngology of the New York University College of Medicine.

DR. JESSE E. HOBSON, head of the department of electrical engineering of the Illinois Institute of Technology, has been appointed director of the Armour Research Foundation of the institute to succeed Harold A. Vagtborg, who on January 1 will become president of the Midwest Research Institute in Kansas City.

DR. HOWARD C. HOPPS, of the School of Medicine of the University of Chicago, has been appointed professor of pathology and chairman of the department of the School of Medicine of the University of Oklahoma. He succeeds Dr. Louis Alvin Turley, who has retired with the title emeritus.

DR. J. DOUGLAS REID, associate professor of bacteriology and parasitology at the Medical College of Virginia at Richmond, has been appointed acting head of the department. He succeeds Dr. Frederick W. Shaw, who was recently appointed research professor of bacteriology.

AT Iowa State College Dr. Alexander M. Mood, who has been working at a special Navy project at Princeton University, formerly a member of the faculty of the American University, has been appointed associate professor in the department of statistics.

PROFESSOR H. T. FLINT has become Hildred Carlile professor of physics at the University of London. He succeeds Professor W. Wilson, who has served since 1921.

A. V. WILLIAMSON, reader in geography, has been elected to the newly established chair of geography at the University of Leeds.

THE University of Liverpool has established a professorship of child welfare with Professor N. B. Capon as the first incumbent.

DR. GEORGE A. ZENTMYER, assistant plant pathologist at the Agricultural Experiment Station at New Haven, Conn., has resigned to accept a similar position at the Citrus Experiment Station of the University of California. He succeeds the late William T. Horne.

DR. FRANK B. JEWETT, president of the National Academy of Sciences, has retired as chairman of the board of the Bell Telephone Laboratories. His address is Care of the National Defense Research Committee, Room 6517, 350 Fifth Avenue, New York 1, N. Y.

DR. VIRGIL P. W. SYDENSTRICKER, professor of medicine at the School of Medicine of the University of Georgia, has been given leave of absence for six months to enable him to accept a commission with the rank of colonel as chief counsel in the nutrition of western Europe of the United Nations and Rehabilitation Administration. He will have charge of organizing the health service of the nations west of the Balkans that have been freed from German control.

DR. ROBERT B. WOODWARD, of Harvard University, will address the New York Section of the American Chemical Society on the evening of December 8 at a meeting to be held at the School of Education of Washington Square College, New York University. His subject will be "The Total Synthesis of Quinine."

BRIGADIER JOHN RAWLINGS REES, consulting psychiatrist to the British Army, on November 20, 21 and 22 delivered the Salmon Lectures for 1944 at the New York Academy of Medicine. The general title of the lectures was "The Shaping of Psychiatry by War."

DR. F. J. W. ROUGHTON, fellow of Trinity College and fellow of the Royal Society of London, has been working in the United States on aero-medical problems. He recently delivered a lecture at the University of California on "Some Recent Work on Carbon Monoxide as a Poison and a Physiological Tool."

DR. JAMES HILLIER, research engineer of the laboratories at Princeton, N. J., of the Radio Corporation of America, has been elected president of the Electron Microscope Company of America.

DR. ARTHUR C. BATES, consulting engineer, assistant professor of mechanical engineering at Lehigh University, has been appointed chief engineer of the Roller-Smith Division of the Realty and Industrial Corporation, Bethlehem, Pa.

THE American-Scandinavian Foundation has announced that the Nobel Prizes will be presented at a luncheon to be held on December 10 at the Waldorf Astoria, New York. As already announced in SCIENCE the recipients are Dr. Henrik Dam and Dr. E. A. Doisy, for their work on vitamin K; Dr. Joseph Erlanger and Dr. H. H. Gasser, director of the Rockefeller Institute for Medical Research, for their work on nerves, and Dr. I. I. Rabi and Dr. Otto Stern, for the results of their study of the structure of the atom. The presentations will be made in behalf of King Gustav V by Wollmar F. Bostroem, Minister from Sweden. This will be the first time that Nobel Prizes have been presented in the United States.

THE regular October meeting of the American Mathematical Society was held at Columbia University, New York City, on October 28. Professor Gordon Pall, of McGill University, gave an address entitled "The Arithmetical Invariants of Quadratic Forms." Twenty-nine research papers were presented to the society, nine in person and twenty by title.

THE University of Pittsburgh held the first of a series of annual research conferences on x-ray and electron diffraction on November 3 and 4. In charge was Dr. Herbert E. Longenecker, dean of research in the natural sciences. Taking part were members of the faculty of the university, of the Carnegie Institute of Technology and of the x-ray and electron diffraction laboratories of the Pittsburgh district. Out of town speakers included Professor W. P. Davey, of Pennsylvania State College, and Professor I. Fankuchen, of the Polytechnic Institute of Brooklyn.

THE Eastern Section of the American Federation for Clinical Research on December 9 will hold a meeting under the presidency of Dr. Orville T. Bailey, of the department of pathology of the Harvard Medical School. A full program of fourteen papers will be presented. Fifteen minutes will be allowed for each paper and five minutes for the discussion following it. All members of the medical profession are invited.

THE sixth annual conference of the Institute of Food Technologists will be held at the Hotel Seneca, Rochester, N. Y., on May 21, 22 and 23, 1945, with food technologists of Western New York as hosts. Arrangements for this conference were considered on November 4 at an afternoon and evening regional conference of the Western New York organization. The program is being arranged by a committee under the chairmanship of Dr. C. O. Ball, of the Research Department of the Owens-Illinois Glass Co., Toledo, Ohio. It will consist of invited papers and addresses to be given during six half-day sessions, at three luncheons and at a banquet. Industrial exhibits showing advances in methods and equipment for food processing are planned. Officers for 1944–45 are *President,* Dr. F. C. Blanck, chief research chemist, H. J. Heinz Company, Pittsburgh; *Vice-president,* Dr. R. H. Lueck, director of research, American Can Company, N. Y., and *Secretary-Treasurer,* Dr. George J. Hucker, New York State Agricultural Experiment Station, Geneva, N. Y.

PLANS for promoting the development of a State Department of Conservation of Utah's Natural Resources were considered by the Division of Biological Sciences and of Applied Biological Sciences at the semi-annual meeting held on October 28 of the Utah Academy of Arts and Sciences at Brigham Young University. A motion was passed recommending that a committee be formed to promote the development of such a department as an aid to research in problems of conservation. Dr. A. M. Woodbury, of the University of Utah, presented a plan for its organization.

THE American Society of Anesthetists met in Houston, Texas, on November 2, and, on November 3, at the Medical Branch at Galveston of the University of Texas. At Galveston there was an exhibit of historical material relating to Horace Wells, who on December 11, 1844, first used nitrous oxide for anesthesia.

AT a recent meeting of the Board of Trustees of Baylor University, tentative building plans were approved for the new building for the College of Medicine to be erected at a cost of $1,000,000 on a twenty-acre site in the Medical Center. The fund is a gift to the college by the M. D. Anderson Foundation, which has also provided the sum of $1,000,000 for research to be used during the next ten years. In addition a gift of $500,000 for the ten-year period has been given by the citizens and business firms of the City of Houston.

THE post-war building plans of Queens College, New York City, include a three-story Z-shaped Science Hall to be erected at a cost of $1,400,000 which will contain sixty-eight rooms, including nine chemical and four geological laboratories. A building for hygiene, on which it is proposed to spend the sum of $450,000, is also planned.

A GIFT of £70,000 has been made to the University of Edinburgh by Sir Robert McVitie Grant to found a chair of dermatology. This is the first chair of its kind to be established in Great Britain.

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THE report for 1943–44 of the Committee on Marine Ecology as Related to Paleontology of the Division of Geology and Geography of the National Research Council, of which Dr. Henry S. Ladd is chairman, has been issued in bound mimeographed form.

CHARLES BROTHERTON has given the University of Leeds £1,000 a year for seven years for the establishment of a Brotherton research fellowship in physical chemistry tenable in the department of color chemistry and dyeing; £1,000 a year for seven years for the establishment of a new lectureship in chemical engineering in the department of coal gas and fuel industries, and an additional sum of £1,000 to each of the two departments for the purchase of equipment.

A NEW map of Soviet Russia, the first and only detailed chart of that country with place names in English, has been issued by the National Geographic Society.

DISCUSSION

UTILIZATION OF "PORE SPACES" OF SEMI-PERMEABLE MEMBRANES[1]

DURING the summer of 1941 it was desired to prepare flexible, opaque, but highly reflective, smooth surfaces in order to make a shutter curtain for a reflex type camera without having a separate mirror. Metallic foils were discarded for many reasons, and an attempt was made to deposit metallic silver directly on a flexible plastic.

"Cellophane" was the plastic selected upon which to try the plating process. Several reasons dictated this choice, namely, its flexibility, its relatively great strength in relation to thickness and the ease of obtaining fairly large sheets. The two commonest methods of depositing silver films on glass, *i.e.*, the ammoniated silver nitrate *vs.* acid sucrose process, and the Rochelle salt process, were tried. Silver was deposited when the solutions were poured over the membrane, but the film of metal did not seem to be quite as adherent on the plastic as it is on glass and was entirely too delicate even when protected by a coating of lacquer. The idea was discarded; but later the question came up as to what would happen if the reacting solutions were separated by the membrane. A trial was made, using the ammoniated silver and acid sucrose solutions. A brown deposit began forming in the membrane almost at once, the color depth increasing and gradually changing to a metallic greyish black. At about this point metallic silver (judged by color) began depositing upon both surfaces. The same sequence of events occurred with the Rochelle salt process. Examination of the brown deposit seemed to indicate that it was composed of finely divided metallic silver.

These films with their surface coatings were not satisfactory for the purpose in mind. A third method of obtaining silver films, that is, the one using triethanolamine solution, was tried. In this case, a metallic silver layer was eventually built up that was not on the surface of the membrane. This piece of plastic served admirably as a mirror that would roll up and stand quite a bit of abuse before finally disintegrating.

[1] From the Department of Ophthalmology, Washington University, and the Oscar Johnson Institute.

The foregoing led quite naturally to speculation regarding other metals, and copper was selected as being one of the easiest to deposit. A solution of copper sulfate was separated from a solution of colloidal iron by a membrane. Nothing resulted from this experiment. Then, finely divided metallic iron was substituted for the colloidal suspension and a deposit having a metallic lavender-brown color was formed within the membrane. The particles in this case were very gross and irregular in size, shape and arrangement. The experiments cited led to speculation concerning membranes other than Cellophane and resultants other than metallic deposits.

The author, being interested in photography, selected the photo-sensitive silver salts for the next group of experiments and somewhat more attention was paid to conditions. Half molar solutions were prepared of silver nitrate and of the four halogen sodium salts. Formation of the silver salt was done by covering the bottom of a porcelain-lined developing pan with the silver nitrate solution and laying a large sheet of Cellophane in the pan in such a manner as to prevent direct contact of the sodium salt solution with the silver nitrate. The sodium salt solution was then poured over the Cellophane and a creamy deposit at once began to form within the membrane. The longest practical exposure was roughly thirty seconds, by which time the reaction had proceeded to the exterior layers, and the halogen silver salt made a mass on both surfaces that was adherent and could only be removed with difficulty. The salt-bearing membranes were washed thoroughly in distilled water and dried with some stretching. The Cellophane used in all these experiments came from box wrappings of one sort or another and was so thin that drying had to be done carefully or too much wrinkling occurred. The light-sensitive silver salt membranes were all prepared in the dark-room using a Wratten 'OA' safe light for illumination. After drying, the films were exposed in direct contact with a standard photographic negative for a slightly shorter time than would be used for a "contrast" lantern slide plate. Development was carried out using Eastman's D-72 formula, fixing in Eastman's F-5 acid

fixative formula, washing in tap water and drying. It was found by trial that the D-72 concentrate had to be diluted at least fifty times to work slowly enough to stop the action before overdevelopment occurred and the time of immersion in the developer had to be cut to a matter of seconds. The film procedure finally became one of immersion only long enough for complete wetting, immediate removal and rinsing in water, then observing and quickly stopping the developing action by acid fixative. Fixation was arbitrarily set for five minutes and washing for ten minutes. Drying was by wiping with a towel and manual manipulation to reduce wrinkling. Images were present in all trials for the silver fluoride, silver chloride, silver bromide and silver iodide. The images were within the membranes and very distinct.

The extreme rapidity of development may possibly be due to a radical overexposure instead of to the fact that the developing agent can act through both surfaces of the film. Experiments are under way to determine the validity of this premise.

Examining the image under an oil immersion objective and a 15× ocular, the combination having a total magnification of 1400×, it was seen that the metallic silver particles were very small in size, were regularly shaped like balls, and arranged in what appeared to be an overlapping lattice. The silver particles seemed to be much more regular in size, shape and arrangement than in the standard photographic emulsion. The particles appeared evenly dispersed through the thickness of the membrane in more or less definite layers, each layer slightly different in position from the one above and the one below.

With the foregoing data at hand speculation as to various other membranous materials was aroused. Selecting silver chloride as an easily handled material for deposition, the procedure was tried on freshly prepared collodion, fish swim bladders, "Viscose" sausage tubing and shell membrane from eggs. The reaction proceeded in the same manner as with Cellophane, and upon exposure and development the metallic silver granules were always found in a definite arrangement. The arrangement of the silver granules varied, however, seemingly being dependent on the material utilized as a membrane. With this in mind it is desirable to try the procedure with materials such as gelatine and agar sheets with the prospect of perhaps really seeing the structure of such materials.

It was believed that the same procedure might be used wherever the product of the reaction is less soluble than the reacting substances. With this in mind a very few experiments were done with salts producing relatively insoluble products. Whenever the procedure was tried, it worked as expected, producing granules of very small size always arranged in a pattern similar to that formed with the silver salt in the same membrane.

A matter for speculation is whether a protein solution on one side with a reacting substance calculated to produce a relatively insoluble protein salt or material on the other will form the insoluble substance within the membrane or upon the surface.

It was thought that this process should be submitted for publication as it provides a tool that possibly may not have occurred to those investigating the nature of permeable or semi-permeable membranes. The process might also serve as another means of providing a support and dispersal member for catalytic agents. It might provide a means of introducing therapeutic materials where slow or controlled absorption is desired. The photographic films produced seem to offer something new, however, in the fine grain effect as no usable enlargement shows any granulation; and the rapidity of development, fixing, washing and drying produces a picture in an extremely short time.

I wish to give thanks to Dr. Lawrence Stout, professor of chemical engineering, Washington University, for the suggestion of the possible explanation of the rapidity of development of the photographic film.

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IMPROBABILITY AND IMPOSSIBILITY

IN a communication under the above caption Lecomte du Noüy[1] points out that, after replacing the word "impossible" by "highly improbable," modern physics has, through Heisenberg's principle of indeterminancy, restored the significance of the "impossible" to the microscopic field. Then he goes on to state that there is at least one impossibility in the microscopic field which is implied by the question, "What is the color of the emulsion of an unexposed film?"

It seems to me that this question, properly understood, raises no issue of possibility or impossibility. It does not satisfy Professor P. W. Bridgman's "operational" test, and consequently belongs to that category which he has characterized as meaningless questions.[2] The question, "What color will the emulsion of a particular photographic plate have after it has been exposed to light?" has a meaning, because it may have an answer on the basis of experience and knowledge of the photochemical properties of the emulsion. But du Noüy's question, with the emphasis on the word "is," has no meaning.

[1] Du Noüy, SCIENCE, 100: 334, 1944.
[2] Bridgman, "The Logic of Modern Physics," p. 30; Macmillan Co., 1927.

In a paper on "The Principle of the Unobservable," the present writer[3] formulated criteria by means of which one can determine whether or not a definition or a concept or a proposition is significant. On the basis of these criteria, the concept of the color of an unexposed film is, in the terminology of that paper, logically unobservable; because it contains a logical contradiction. Du Noüy's question asks for the specification of the color of a film, but it rules out exposure to light at any stage of the operation by means of which it may be determined. In other words it, in effect, eliminates the concept of light as an element in the concept of color. But since light is a necessary element of color, the concept of color implied by the question is self-contradictory; consequently, it is logically unobservable; and the question is meaningless.

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IN No. 2598 of SCIENCE Lecomte du Noüy in an effort to illustrate the Heisenberg's principle of indeterminancy tries to present "an observation which would be at the same time practically and theoretically impossible."

He asks a question: "What is the color of the emulsion of an unexposed photographic plate?" and asserts "that we can not know it, and that it will never be experimentally checked."

I do not think that the proposed experiment would serve the purpose, and, therefore, the argument based on this "impossibility" appears to me not convincing.

Every photographic emulsion has its threshold of sensitivity with respect to the duration of an exposure. In many emulsions the exposure of a plate to the light of 1 candle-power for 0.0001 second would produce no chemical change in the emulsion, and, therefore, no change in color of the emulsion layer.

On the other hand, the response of a photo-electric cell to the flux of light of the same intensity is faster than 0.000001 of a second, and, possibly, instantaneous. Therefore, it is possible to devise a photo-electronic colorimeter which, being placed in a camera with the experimented photographic plate, will register and read the color of the light reflected from the plate during 0.0001 of a second.

Furthermore, the belief that "the old determinism received its death blow" is not universal yet. It may be agreed that speed and position of an electron can not be observed simultaneously if a single or few sources of illumination are used. The situation is changed, however, when an infinite number of sources is used which illumine a moving electron from an infinite distance. In such case the impacts of photons (whatsoever their values of hν may be) upon the electron produce a continuous pressure, especially when it is considered that each single photon must embrace an electron completely.[1]

Considering an electron of finite dimensions acted upon by photons of finite velocity, we have to ascribe a finite time to the action of a single photon upon the observed electron. Therefore, there is, at least, a statistical possibility to determine the speed and the position of the electron under observation. The time of a single observation must be less than

$$\frac{\text{diameter of electron}}{\text{velocity of photons}} = \frac{2.10^{-13}}{3\times 10^{10}} = \frac{2}{3}\,10^{-26}\ \text{sec.}$$

This time may be considerably longer if photons have a length.

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SCIENTIFIC BOOKS

MITOSIS

Mitosis. By FRANZ SCHRADER. 110 pp. New York: Columbia University Press, 1944.

MITOSIS, like photosynthesis and certain other familiar processes, has long presented one of biology's standing riddles. And it still does. Why this is so is ably brought out in Professor Schrader's thoughtful monograph. The author has performed a valuable service in bringing together the ramifying literature in this field and subjecting it to critical analysis. As the sub-title indicates, the treatise is restricted to chromosomal phenomena and deals with cytoplasmic constituents only in so far as they are directly involved in the mitotic process. Viewing the monograph as a whole the reader will perhaps find the following four characteristics especially prominent: (1) Brevity. The size of the volume (only 86 pages in the text, and large print) precludes full treatment of the subject and whets the appetite for the type of survey which the author's 18-page bibliography shows he is prepared to give. (2) Emphasis on recent work and on the modern viewpoint of the biochemist and biophysicist. (3) Skilful treatment of the numerous aberrant types of mitotic behavior which must be considered along with the standard ones before any adequate conception of intracellular kinetic activities can be obtained. This treatment the author is, of course, uniquely fitted to give. (4) Recognition and revelation of the extraordinary complexity of the mitotic

[3] Dadourian, *Scientific Monthly*, 293, 1944.

[1] H. A. Lorenz, *Phys. Ztschr.*, 1910, s. 355.

process and the difficulty of explaining chromosome movements on the basis of any one simple principle.

Aside from a three-page introduction and a conclusion of similar length, the text consists of three chapters. Two of these, one on the structure of the mitotic apparatus and one on hypotheses of mitosis, make up the body of the work. The third, of 9 pages, deals with "related problems" which serve to emphasize the fact that mitosis is itself a part of a larger cycle representing a "highly involved complex of processes" extending through the entire cell generation.

In considering the origin and structure of the components of the mitotic apparatus evidence is reviewed from living as well as fixed material and from experiments as well as direct observation. Although not all present in all cells, the main components such as centrioles, astral rays and spindle fibers are real and exist in the living cell. The incompleteness of our knowledge of such structures, however, is "in a sense a measure of our ignorance of the forces of mitosis."

Two main types of mitotic spindles are recognized, with accompanying differences in the mechanics of chromosome movement. In the "direct" type the chromosomes are connected directly with the poles by means of "chromosomal" spindle fibers and are guided, if not actually pulled, to the poles thereby. In the "indirect" type the chromosomes are connected with "continuous" fibers (which have arisen independently between the poles) and slide along these fibers to the poles. "An element of fundamental importance in the movements of chromosomes" but one which has only recently "received the attention which it merits" is "the kinetochore or centromere" (point of spindle fiber attachment on the chromosome). Observations and interpretations as to its structure differ so much, however, that any broad consideration "must at present stand largely on hypothetical grounds." The probable homology between the kinetochore and the astral centriole is brought out and numerous illuminating departures from "orthodox" conditions are reviewed, including those involving multiple or diffuse kinetochores. Astral rays and the "continuous fibers" of the spindle are regarded as similar in structure and origin and as probably representing lines of flow in which "the long molecules of the ground substance are oriented in parallel rows so as to form fibrous configurations."

In considering hypotheses of mitosis, events leading up to metaphase are treated separately from those that follow because different types of movements are involved. "It is indicative of our ignorance that we can not see the bearing that the problems of prophase and interphase have on the points that puzzle us in metaphase and anaphase." Comparison of the evidence on spindle fibers with that on myofibrils suggests that both may contract by means of "fundamentally the same mechanism—namely, a change in the shape of a protein chain. . . ." Hypotheses involving both a contraction and expansion of spindle constituents are becoming increasingly plausible because of the newer concepts of the changes in form of protein chains. The complexities and difficulties inherent in the problem of mitosis are well brought out by the author's discussion of views attributing chromosome movement to changes in viscosity or hydration of protoplasmic materials or to electrostatic forces. The latter forces furnish the best theoretical explanation of the events of mitosis but at the same time make "a glaring exposure of our ignorance concerning the physical chemistry of the cell. . . ." Diffusion currents and regional currents in the spindle, hydrodynamic forces, and recent evidence on tactoids are all considered, but again the handicap is lack of evidence to support the hypotheses.

Special attention is given to the possibility "that the mitotic movements of chromosomes are largely autonomous" and "that the forces involved reside or originate in the chromosomes themselves," a view which has acquired some prominence "through the study of special cases which rule out any explanation based on contraction, expansion, streaming or electrical forces" and also receives support from earlier experimental evidence.

The work closes with a three-page conclusion in which the inadequacy of all current hypotheses is balanced against the fact that probably the majority of hypotheses "have a portion of truth in them." The inherent difficulties in the experimental method of attack are cited and promising lines of future investigation are depicted. The latter section not only lends a final cheerful and encouraging tone to the survey but will be of practical value to future investigators.

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REPORTS

SMITH COLLEGE CONFERENCE ON PLANT EMBRYO CULTURE[1]

A CONFERENCE on the culture of embryos and other excised plant tissues was held at Smith College, Northampton, Mass., for two and a half days, from July 14 to 16. The meeting was organized by the Smith College Genetics Experiment Station on a somewhat different plan from that of most scientific gatherings. There were no prepared papers and no

[1] Contributions from the Department of Botany, Smith College, New Series, No. 14.

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speeches with a distinction between a speaker and an audience and the sessions were not open to the biological public. Instead the 36 specialists who attended[2] sat around a large table and took part in a free back-and-forth discussion of topics in which they could exchange experiences and make suggestions toward the solution of problems involved in the artificial cultivation of tissues apart from the parent plant.

The program was varied by trips to the Smith College Genetics Experiment Station, to the Massachusetts State College and Agricultural Experiment Station and by a tea given by President and Mrs. Herbert Davis, of Smith College, to those who attended the conference and to members of the biology departments of the four neighboring colleges—Amherst, Mount Holyoke, Massachusetts State and Smith. Smith College provided lodging for the conferees in guest rooms of the college dormitories. Other expenses of the conference were cared for by a grant from an outside source.

One of the features of the conference which met with general approval was its informality and lack of restraint that might have ensued if the members had felt their remarks were to be published. A suggestion that a detailed report of the proceedings should be assembled and sent around to those who attended was voted down. It was felt, however, that publication of a brief note on the organization of the conference and the topics discussed would be desirable.

An agenda was prepared and sent to the conferees before their arrival, which served, with slight modifications, as a basis for consideration of the problems which were brought up during the sessions. For each main topic a chairman was suggested who led in the discussion of the subject in which he was especially familiar. Speeches, however, were barred, and there was no transgression against the definition that a monologue continued for five minutes would be classified as a speech.

[2] The investigators from other institutions were: James Bonner, A. J. Haagen-Smit and R. Siu, California Institute of Technology; Lewis Knudson, L. F. Randolph and L. G. Cox, Cornell; Ernest Ball, A. O. Dahl, P. R. Gast, H. J. Sax, Karl Sax and R. H. Wetmore, Harvard; R. E. Cleland, Indiana University; J. van Overbeek, Institute of Tropical Agriculture, Puerto Rico; F. K. Skoog, Johns Hopkins; H. B. Tukey, New York State Agricultural Experiment Station at Geneva, N. Y.; R. F. Dawson, Princeton University; P. R. White, Rockefeller Institute at Princeton; W. G. Whaley, U. S. Department of Agriculture; Carl La Rue, University of Michigan; J. W. Marvin, University of Vermont; R. A. Brink, D. C. Cooper and A. J. Riker, University of Wisconsin; Hempstead Castle and E. W. Sinnott, Yale. Those from the Smith College Genetics Experiment Station were: A. F. Blakeslee, Sophie Satina, A. G. Avery, Sara Bache-Wiig, Lenette Atkinson and the following student assistants: Jean Cummings, Susanne McLean, Peggy Lieb, Mary Sanders and Carmen Sanz.

While naturally the discussions touched largely on matters of technique, it was early emphasized that the broad objective of fundamental importance toward which the conference might contribute was an understanding of factors in growth and differentiation from development of the egg through the embryo to the seedling and adult organs of the plant. Emphasis in the discussions was placed upon embryo culture, but similar problems are involved in the cultivation of other plant tissues in the study of which there were several specialists who took part in the conference.

The following main headings, which were further subdivided in the agenda, served as a basis for the detailed discussions: What each is doing and why; Objectives; Applications in genetics engineering; Instruments and methods of dissection; Seed dormancy relieved by embryo culture; Possible barriers to crossability; Morphological changes in growth and differentiation of embryos *in vivo* and *vitro;* Abnormalities in hybrid embryos; Micrografts; Infection by bacteria and molds; Why embryos fail to develop after starting; Physical requirements of media; Inorganic requirements; Organic requirements; Chemical nature of "Embryo Factor"; Effect of stage of development on nutrient requirements; Speeding up growth at different stages; Possibility of cultures in injected capsules; Special problems.

Those of us in the Smith College Genetics Experiment Station profited greatly from the many suggestions and new points of view that came out of the conference. This feeling of the value of the opportunity for exchange of ideas in a field in which all the conferees were actively carrying on research appeared to be shared by all who attended. The discussions at the conference gave evidence that increased research in embryo culture may be expected.

One has characterized the conference as "the most productive of any similar session which I have ever attended and I believe it is not too much to say that it has laid the foundation for the science of plant embryology in the modern sense." Whatever influence the conference may have on the future trend of botanical research it showed clearly to us who took part in its sessions that the problems of plant growth and development may be profitably attacked by experimental procedures, that development is controlled through a progressively changing internal environment, that an understanding of the environmental factors involved may be aided by study of tissues in cultures apart from the parent plant, and that further knowledge of these factors may lead to conscious control of a wide range of life processes.

Albert F. Blakeslee
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SPECIAL ARTICLES

THE CHOLINESTERASES IN THE LIGHT OF RECENT FINDINGS

WHEN Alles and Hawes,[1] continuing the work of Galehr and Plattner,[2] observed that the cholinesterase of human red blood cells was far more active at low than at high concentrations of acetylcholine and that the reverse was true for the cholinesterase of human serum, they were led to believe that erythrocytes contained one type of enzyme, "cell cholinesterase," while the cholinesterase found in serum represented another type, "serum cholinesterase."

Of the above experiments those concerning the enzyme in red blood cells were interpreted correctly by the authors; their assumption, however, that the cholinesterase in serum is homogeneous and represents the "serum type" enzyme proved to be incorrect, since a serum devoid of "cell cholinesterase" has as yet not been found. Serum of man, it is true, contains predominantly "serum cholinesterase" and only comparatively small amounts of "cell cholinesterase," but fairly large quantities of "cell cholinesterase" are present in the sera of dog, cat, guinea pig, rabbit and rat.[3,4] Had Alles and Hawes examined the sera of ruminants (ox, sheep),[3] they would have found that the only cholinesterase contained therein is, according to their nomenclature, "cell cholinesterase"—a reductio ad absurdum of a classification of cholinesterases based on their locale.

Our work, which finally resulted in a definite differentiation between two cholinesterases, was prompted by the question whether a specific enzyme or a non-specific esterase hydrolyzes acetylcholine in the animal body. Since this question could only be answered by closely examining the enzyme in all its peculiarities, purification became a matter of necessity. Highly purified enzyme preparations were obtained,[5,6,7] and it was the difference in the properties of these preparations which made it clear beyond doubt that two distinct cholinesterases exist in the animal body: a specific or true cholinesterase, hydrolyzing choline esters exclusively, and a non-specific or pseudo-cholinesterase capable of hydrolyzing a variety of esters, including those of choline.[5]

These experiments, which revealed the intrinsic properties—specificity and non-specificity—characteristic of the two cholinesterases throughout the animal kingdom, at the same time disclosed another difference between the two enzymes: the true cholinesterase, in contrast to the non-specific enzyme, was found to display a far greater activity at low than at higher concentrations of acetylcholine. This peculiarity of the specific enzyme, though conspicuous in mammals, fades, however, as we descend the evolutionary scale and is no longer encountered in the true cholinesterase present in primitive forms of life, *e.g.*, in Planaria.[8] Decreasing activity with rising substrate concentrations should therefore not be considered an inherent property of the specific enzyme.

Furthermore, we have recently found[9] that the activity-substrate concentration curve of the true cholinesterase can be changed at will and even reversed by adding to the enzyme solution certain organic colloids capable of reversing the electric charge of the enzyme particles—a fact which might have some bearing on the theory of nerve impulse transmission. Protamines, for example, carrying a strong positive charge are able to change the activity-substrate concentration relationship of the true cholinesterase in mammalian brain to such an extent that the enzyme, now resembling the pseudo-cholinesterase, displays increasing activity with rising substrate concentrations (see Fig. 1). Subsequent addition of negatively

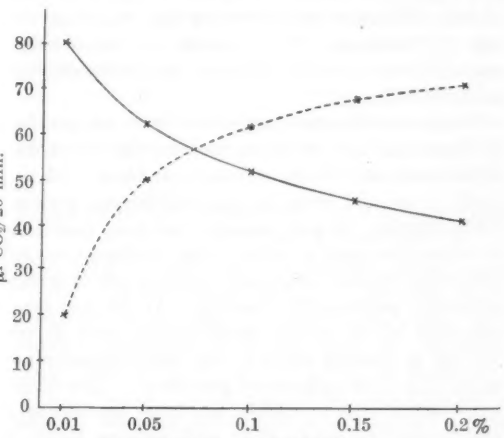

FIG. 1. Effect of protamine on the activity-substrate concentration curve of true cholinesterase (dog brain cortex). Activity determined manometrically by Warburg's method. 0.1 ml of a suspension of ground cortex (1 part in 3 parts of water) in 5.0 ml 0.025 M sodium bicarbonate saturated with 5 per cent. CO_2 in N_2

without ————,

with 1 mg. clupein sulphate .....

[1] G. A. Alles and R. C. Hawes, *Jour. Biol. Chem.*, 133: 375, 1940.

[2] O. Galehr and F. Plattner, *Pflüg. Arch. ges. Physiol.*, 218: 488, 1928.

[3] B. Mendel, D. B. Mundell and H. Rudney, *Biochem. Jour.*, 37: 473, 1943.

[4] D. B. Mundell, *Nature*, 153: 557, 1944.

[5] B. Mendel and H. Rudney, *Biochem. Jour.*, 37: 59, 1943.

[6] B. Mendel and D. B. Mundell, *Biochem. Jour.*, 37: 64, 1943.

[7] F. Strelitz, *Biochem. Jour.*, 38: 86, 1944.

[8] B. Mendel and R. B. Hawkins. To be published shortly.

[9] B. Mendel and H. Rudney, paper presented before Toronto Biochemical and Biophysical Society, April 15, 1943.

charged colloids, *e.g.*, gum acacia, to the protamine-treated true cholinesterase restores the original activity-substrate concentration relationship.

The change in the activity curve of the true cholinesterase, brought about by the addition of protamines, in no way affects the fundamental property of the enzyme, its specificity towards choline esters. This shows that the activity-substrate concentration relationship is but a secondary characteristic of the enzyme, determined by its physical environment, whereas the specificity of the enzyme, unchangeable irrespective of environmental conditions, is an inherent property of the true cholinesterase.

Thus, a classification of cholinesterases according to their locale or to their activity-substrate concentration relationship, though seemingly expedient, is at variance with the facts and will inevitably lead to confusion. Specificity alone, therefore, remains the true criterion for a differentiation of cholinesterases.

Alles and Hawes contend that "the findings of Glick on the behavior of the enzyme of the cat superior cervical ganglion, make the acceptance of 'pseudo-cholinesterase' as a suitable name for the serum enzyme seem inadvisable."[10] If the enzyme activity of the superior cervical ganglion were, in fact, due to pseudo-cholinesterase alone, such findings would indeed support the contention of Alles and Hawes. Our experiments, however, have shown that a mixture of both cholinesterases occurs in this ganglion, the true cholinesterase being present in considerable amounts in the ganglion of the cat and predominating in that of the dog.[11]

Further experiments performed by us on pseudo-cholinesterase have tended to minimize the importance of this enzyme. We have found that blood[3] and tissues[12] of ox and sheep do not contain any pseudo-cholinesterase. In rats, moreover, we have been able to reduce the activity of the pseudo-cholinesterase of serum and tissues considerably without effecting any noticeable physiological changes. An 80 per cent. reduction of the pseudo-cholinesterase level in the rat can be brought about by the oral administration of 5 g/Kg of tri-ortho-cresyl phosphate. This chemical, which is toxic to rabbits, was found by Hottinger and Bloch[13] to reduce their cholinesterase level; it does not, however, produce any symptoms in rats, whose true cholinesterase, according to our experiments,[12] is insensitive to tri-ortho-cresyl phosphate—a fact which may help to explain the absence of toxic effects in these animals.

Despite the above findings, the name pseudo-cholinesterase was not chosen to detract from the significance of the non-specific enzyme. The term cholinesterase was retained in order to provide continuity with the earlier mass of literature on this subject, while the prefix "pseudo-" was selected to emphasize the intrinsic property of non-specificity and to avoid the hitherto indiscriminate application of the term cholinesterase, suggestive of specificity towards choline esters.

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[10] G. A. Alles and R. C. Hawes, SCIENCE, 100: 75, 1944.
[11] H. Rudney. To be published shortly.
[12] B. Mendel, J. M. Gunter and E. Mortimer. To be published shortly.
[13] A. Hottinger and H. Bloch, *Helv. Chim. Acta*, 26: 142, 1943.

THE ANTIBACTERIAL ACTION OF PENICILLIN AGAINST GRAM NEGATIVE ORGANISMS[1]

SINCE the discovery of penicillin and the subsequent demonstration of its antibacterial activity *in vivo*, considerable interest has centered on the group of bacterial agents susceptible to its action. Fleming reported in 1929[2] that penicillin possessed a marked bacteriostatic effect against many of the Gram positive organisms, including staphylococci, streptococci and the diphtheria bacillus. This observation was confirmed by Chain *et al.*[3] in 1940 and the list of susceptible organisms extended by Hobby *et al.*[4] and by other workers. With the exception of the meningococcus and gonococcus, however, no activity could be demonstrated against Gram negative organisms.

In 1941 Kocholaty[5] demonstrated that *Penicillium notatum*, from which penicillin is formed, produced a second substance, notatin (also known as penatin, penicillin B or *E. coli* factor) which possessed an antibacterial action against Gram negative as well as Gram positive organisms. It was subsequently shown, however, that notatin is an enzyme effective only *in vitro* in the presence of glucose.

In 1944 Helmholz and Sung[6] demonstrated a weak bactericidal effect of penicillin in urine on *Streptococcus fecalis* and on *Proteus ammoniae* but not on *E. coli* or Aerobacter aerogenes.

In the present communication preliminary data are presented to demonstrate that penicillin produced by *Penicillium notatum* or *Penicillium chrysogenum* possesses an antibacterial action *in vitro* against other Gram negative organisms and is effective in the absence of glucose.

[1] From the Biological Laboratory of Charles Pfizer and Co., Brooklyn, N. Y.
[2] A. Fleming, *Brit. Jour. Exp. Path.*, 10: 226, 1929.
[3] E. Chain *et al.*, *Lancet*, 2: 226, 1940.
[4] G. L. Hobby, K. Meyer and E. Chaffee, *Proc. Soc. Exp. Biol. and Med.*, 50: 227, 1942.
[5] W. Kocholaty, *Jour. Bact.*, 46: 313, 1943; *Arch. Biochem.*, 2: 73, 1943.
[6] H. F. Helmholz and Chieh Sung, *Proc.* of the Staff Meetings of The Mayo Clinic 19(14): 370, 1944.

Experimental: Preliminary experiments were carried out by the serial dilution method[4] using a stock strain of *E. typhosus* as the test organism. Plain beef infusion broth was used throughout.

One hundred and seventeen crude liquors, prepared by the cultivation of *P. notatum* or *P. chrysogenum* in a medium suitable for penicillin production, and eighty-six partially purified penicillin solutions were tested. The potency of these liquids ranged from 35 to 49,000 Oxford Units per cc. All the crude liquors showed some degree of bacteriostatic activity when tested in low dilutions against *E. typhosus*. The partially purified fractions, containing higher concentrations of penicillin, inhibited growth of *E. typhosus* in dilutions from 1:400 to 1:32,000.

In subsequent experiments the crystalline sodium salt of penicillin (G) was tested by the double serial dilution method for bacteriostatic action against both *Staphylococcus aureus* and *E. typhosus*. It was found that this preparation of penicillin was 64 times more potent against *Staphylococcus aureus* than against *E. typhosus*. On this basis crystalline penicillin sodium, having a potency of 1,650 Oxford Units per mg against *Staphylococcus aureus*, was chosen as standard and a value of 26 Typhoid Units per mg assigned to it. All subsequent tests for activity against *E. typhosus* were carried out by the Oxford cup method[7] using a substandard, established at 7 Typhoid Units per mg by titration against the crystalline penicillin sodium. Plain beef infusion agar containing neither glucose nor cerelose was used throughout. Table 1 shows the results on a number of fractions tested.

TABLE 1

BACTERIOSTATIC ACTION OF PENICILLIN AGAINST E. TYPHOSUS

Preparation of penicillin*	Potency against *Staphylococcus aureus*	Potency against *E. typhosus*
	Oxford Units/cc	Typhoid Units/cc
Crude liquors	> 35	0.5–2.0
Partially purified fractions	5,970–13,980	74–92
Liquid concentrates	32,000–49,000	50–800
	Oxford Units/mg	Typhoid Units/mg
Dried penicillin "Commercial"	620–993	7–20
Crystalline penicillin sodium	1,650	26

* All penicillin tested was prepared by Chas. Pfizer and Company, Brooklyn, N. Y.

A variety of Gram negative organisms,[8] in addition to *E. typhosus*, were tested for sensitivity. Table 2 shows the relative susceptibility of the organisms tested. Only two strains of Gram negative organisms, a strain of *E. coli* which produces large amounts of penicillinase and a freshly isolated strain of *Ps. pyocyaneus* were completely resistant.

TABLE 2

RELATIVE SUSCEPTIBILITY OF GRAM NEGATIVE ORGANISMS TO ACTION OF PENICILLIN

Strain	Typhoid units per cc causing inhibition
E. typhosus (3 strains)	0.016
Sh. dysenteriae Flexner (V)	0.031
S. paratyphi B*	0.125
Sh. dysenteriae Flexner (W)*	0.125
*S. panama**	0.125
Sh. dysenteriae Flexner (Y)*	0.250
Sh. dysenteriae Flexner (X)*	0.250
Sh. dysenteriae Flexner (Z)*	0.500
Proteus vulgaris	0.500
Br. abortus	0.700
Klebsiella pneumoniae	> 1.400†
Serratia marcescens	> 1.400†
Ps. aeruginosa	> 1.400
E. coli	> 1.400

† Complete inhibition of growth was observed with 62 T.U./cc.

* Cultures were typed by the Salmonella Center, Beth Israel Hospital, New York, N. Y.

The antibacterial action of penicillin against *E. typhosus* is destroyed by clarase, which contains penicillinase, and is partially or completely destroyed at 100° C. for 1½ hours.

Summary: It is apparent that penicillin exerts an antibacterial action against Gram negative as well as Gram positive organisms. This property of penicillin becomes more apparent in high potency preparations. It is possible that a form of penicillin showing greater activity against Gram negative organisms may exist. Studies on the nature of such a substance and on the *in vivo* action of penicillin against Gram negative organisms are in progress.

GLADYS L. HOBBY

RELATION OF DOSAGE TO SURVIVAL TIME OF ARSENITE-INJECTED ROACHES

IN a study, carried on during the last several years, of the mode of action of sodium metarsenite on the American cockroach, *Periplaneta americana* (L.), various concentrations of the poison in volumes of saline proportional to body weight of the insect were injected into the roaches and the survival times determined. When the survival times were plotted against concentrations, hyperbolic curves were obtained. A portion of one of these is shown in Fig. 1. These curves are characterized by a region of inflection (*i*, Fig. 1) and a critical zone, both of which are reproducible in repeated experiments. The critical zone is a region, usually associated with long survival times, in which insects injected with equal doses of the poison have survival times that fall into a bimodal frequency distribution or actually into two separate groups. In the region of inflection, injection of slightly different concentrations of the poison may

[7] W. H. Schmidt and A. J. Moyer, *Jour. Bact.*, 47: 199, 1944.

[8] These cultures were received through the kindness of Dr. Hattie Alexander, Babies Hospital, New York, N. Y.

cause the same survival time or the lower dosage may cause the shorter survival time. This anomaly, that the lower dosage may be more toxic than the higher dosage, receives a rational explanation in terms of a proposed hypothesis regarding the role of dissociation[1] in the mode of action of the poison.

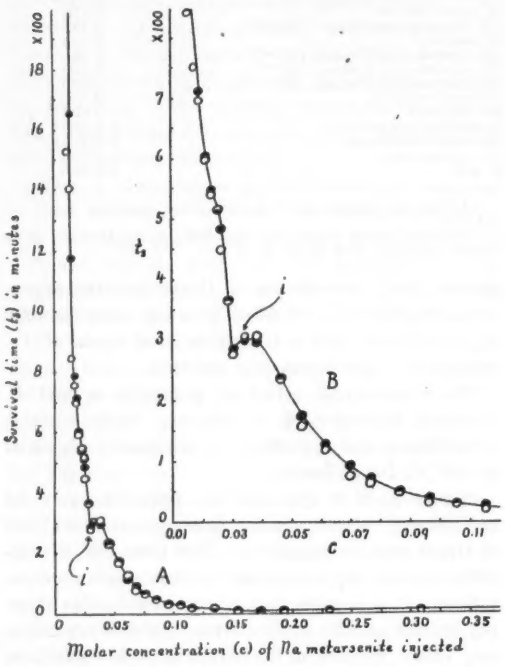

FIG. 1. A concentration-survival time curve of *Periplaneta americana* injected with Na metarsenite. Curve *B* is part of curve *A* on a larger scale to show better the region of inflection, *i*. Circles: Harmonic means of observed t_s. Solid dots: Survival times calculated by equation (2).

It is postulated that the toxic action is dependent upon the degree of ionization of the poison; that the arsenical ion thus formed, or a secondary material itself dependent upon the formation of the arsenical ion, combines with certain vital tissue components in what is here designated a fundamental lethal reaction; that the fundamental lethal reaction leads to the death of the insect; and that the death of the insect takes place as a result of a certain minimum quantity of the arsenic combining with a unit quantity of the tissue component.

An examination of the literature shows that hyperbolic dosage-survival time curves are sometimes described by use of equations of the type $ct = k$ and $(c - c_o)\ (t - a) = k$. Such relatively simple expressions have not yielded good fits to our experimental data. Good fits can be obtained by use of equations developed by the authors and which are essentially the well-known equation $(c - c_o)^n\ (t - a) = k$ so modified that the influence of dissociation is taken into account.

In accordance with the above postulates, let it be assumed that the sodium metarsenite dissociates with the formation of an arsenical ion and suppose (tentatively) that this ion combines with the tissue component to cause the death of the insect. If t_s = survival time, c' = concentration of the arsenical ions, c_o = the highest concentration of the poison that fails to kill and a = the shortest survival time theoretically possible, it may be postulated in accordance with the data that the rate of change of survival time with respect to the effective concentration of the poison is inversely related to a power, n', of the effective concentration, *i.e.*, $-d(t_s - a)/d(c' - c_o) = k'(c' - c_o)^{-n'}$. When integrated this becomes $t_s - a = K\ (c' - c_o)^{-n}$, where $K = k'/n$ and $n = n' - 1$. The concentration corrected for dissociation is $c' = pc + c(1-p)\left(\frac{c_d}{c}\right)^m$, where p is the proportional ionization of the poison at the highest concentration that can be used, c is the concentration of poison injected, c_d is the highest concentration at which complete dissociation of the poison takes place, and m is a constant. Fully expressed, the equation is

$$t_s = \frac{K}{\left(\left[pc + c(1-p)\left(\frac{c_d}{c}\right)^m\right] - c_o\right)^n} + a. \qquad (1)$$

In equation (1), pc is the concentration of ions and $c(1-p)$ that of the undissociated molecules proportional to that in the highest total concentration of the poison, and $\left(\frac{c_d}{c}\right)^m$ is a factor that determines the rate at which additional ions are formed from the molecules as c decreases and as ions are removed from the body fluid in the fundamental lethal reaction. The factor $\left(\frac{c_d}{c}\right)^m$ may attain but not exceed 1.

Fits obtained by use of this equation are good, except in the critical zone and when survival time is very long. The fit at this end of the curve can be improved somewhat by use of an equation which will be referred to as equation (2), and which is like equation (1) except that a bounded variable $\bar{c}_o$, directly proportional to a power of the corrected concentration and directly proportional to survival time, is substituted for the constant c_o, where

$$\bar{c}_o = k\left\{\left[pc + c(1-p)\left(\frac{c_d}{c}\right)^m\right]^b \left[pc + c(1-p)\left(\frac{c_d}{c}\right)^m\right]^{-n}\right\} = k\left[pc + c(1-p)\left(\frac{c_d}{c}\right)^m\right]^s,$$

$s = b - n$, and b is a constant. But neither equation

[1] In using "dissociation" the authors have in mind also the concept of "activity." It makes no material difference in their analysis whether the poison is considered to "dissociate" partially, or to dissociate completely into ions only a percentage of which are "active."

takes into account certain factors, such as the finite mortality of the controls, operative at this extremity of the curve.

In Fig. 1 survival times (solid dots) were calculated by equation (2) to fit the observed survival times (open circles). It should be noted that the agreement is good even in the region of inflection. A detailed analysis of the entire experimental data, a discussion of the theory underlying the development of equations (1) and (2), and a consideration of these results with respect to the literature are included in manuscripts in preparation or unpublished. It is believed that these equations are of general applicability in studies involving the action of compounds, such as sodium metarsenite, that exist in solution in two different forms related by a condition of equilibrium. The good fits obtained by use of these equations support the underlying hypothesis and indicate that the effective concentration is not necessarily the concentration of the poison that is injected into the insect. They also support the explanation that the anomaly represented by the region of inflection is the result of the rate of dissociation of the poison as concentration changes and as the fundamental lethal reaction goes on.

J. FRANKLIN YEAGER
SAM C. MUNSON

THE MOTION OF SMALL PARTICLES IN MAGNETIC FIELDS

As reported by Ehrenhaft[1] rotational motions have been observed in a constant vertical homogeneous magnetic field using an electromagnet with the pole pieces immersed successively in ferric chloride, copper sulfate and slightly acidulated water. The material in motion consisted of charged particles and bubbles. The speed of rotation was a function of magnetic field intensity. Polar movements of particles of iron and nickel in a gas were observed in a constant vertical homogeneous magnetic field. These movements occurred both with and against the gravitational field and took the form of spirals, parts of spirals or vertical lines.

The fact that solutions of non-uniform concentration or of different layers of concentration will rotate under the action of an inhomogeneous magnetic field has been noted by many observers. Among these is Urbasch,[2] whose work has been commented on by Drude,[3] and the more recent observations of Kendall.[4]

The authors have repeated the experiments on motions in liquids and gases reported by Ehrenhaft and have performed further experiments to study these phenomena. In these experiments the authors have used solutions of uniform concentration or single particles and a homogeneous magnetic field, as did Ehrenhaft. Unless otherwise stated, all observations were made with a microscope[5] employing dark field illumination. The various liquids were placed in a glass cell and the illumination was directed from either side perpendicularly to the line of observation, being supplied by arc lamps with suitable lenses and cooling cells (see sketch). The microscope was usually fitted with a 3X objective and a 4X ocular, though a wide variety of lenses was available and used.

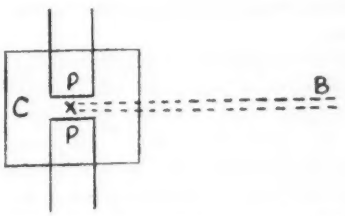

FIG. 1. C—Cell used to hold liquids; PP—Pole pieces; B—Illuminating beam; X—Point under observation. Line of observation is directed perpendicularly into plane of paper.

The electromagnet was constructed in the shape of a rectangle. Three sides of the rectangle, forming a U, had a cross-sectional area of 6 cm². The fourth side was completed by detachable pole pieces. On each leg of the U was placed a coil of 9,600 turns of No. 26 B. & S. copper wire. The field could be varied from zero up to 20,000 gausses and was reversible. The coils could be connected singly, in series or in parallel. The current could be varied from zero to two amperes. The separation between the pole pieces was ordinarily from one to two millimeters. The pole pieces were 8 millimeters in diameter. The permanent magnets used were Alnico "Blue Streak" having a total flux of 17,000 to 18,000 maxwells.

In experiments using the electromagnet rotational motions were observed in the following solutions: barium hydroxide, potassium hydroxide, sodium hydroxide, sodium chloride, potassium chloride, sodium fluoride, cupric cyanide, potassium cyanide, 1 per cent. hydrochloric acid, ferrous chloride, ferrous sulfate, ferrous ammonium chloride, ferrous ammonium sulfate, cadmium sulfate, cobalt nitrate, cobalt sulfate, nickel nitrate, nickel sulfate, a suspension of copper in copper sulfate, suspensions of iron, manganese, tungsten, zinc, aluminum, chromium, cobalt, nickel, copper, lead and brass in distilled water, a suspension

[1] F. Ehrenhaft, *Phys. Rev.*, 63: 461; 64: 43, 1943; 65: 287, 1944; *Nature*, 3909: 426, 1944.

[2, 3] O. Urbasch and P. Drude, *Zeits. f. Elektrochemie*, 7: 114, 1901; 8: 65, 150, 229, 1902.

[4] J. Kendall, *Nature*, 3587, 157, 1944.

[5] *Ibid.*, footnote 4, page 1.

XUM

of aluminum in isopropyl alcohol and numerous other solutions. In many of these solutions dual rotations against each other in the same plane and at the same time were observed. In others this was not observed. Without exception, however, the direction of rotation was reversible with reversal of the field and the speed of rotation was a function of magnetic field strength. Pole pieces of nickel, cobalt and iron were available.

Polar movements in a gas in a constant vertical homogeneous magnetic field were observed. Manganese, tungsten, chromium, nickel, cobalt, copper, aluminum, zinc, lead and brass particles were used. With some metals, such as tin, antimony and bismuth, no movement was observed. Where such polar movements were obtained, all tracks were spirals or parts of spirals.

In another experiment, a suspension of manganese was prepared in a high-grade oil. Spiral tracks of these particles were observed traveling with and against the gravitational field. All these particles moved at approximately the same rate of speed and all terminated their movement on one or the other of the pole faces.

The following experiments were performed using a permanent magnet: Soft iron pole pieces fitted to the permanent magnet were immersed successively in ferric chloride, ferrous chloride, copper sulfate, potassium chloride, sodium chloride, sodium bicarbonate, cobalt sulfate and cobalt nitrate. Rotational motions were observed in each case. Reversal of the magnet reversed the sense of rotation.

At Ehrenhaft's suggestion, the following two experiments were performed: The pole pieces of the permanent magnet were arranged so that only the lower pole was immersed in a solution of ferric chloride. The upper pole was adjusted so that it barely cleared the solution. A rotational motion of the entire liquid was plainly visible without the aid of a microscope. The two pole pieces were then removed and a single soft iron rod was placed across the magnet, a glass cell having been fitted to the center of the rod. This cell was filled with ferrous chloride and a slow rotation of the entire solution was observed. In a variation of the above experiment, the authors immersed the pole pieces in a copper sulfate solution. The rate of rotation was noted and keepers were placed on the magnet. The speed of rotation decreased as the area of the keeper in contact with the magnet was increased.

One of the most beautiful and striking effects was obtained by separating the pole pieces by a distance of about 2 millimeters. A drop of copper sulfate was placed in the gap, the drop filling the entire space between the poles, surface tension causing it to remain in place. The shape of the drop approximated that of an hourglass. The ratio of length to width at the midpoint was dependent on the size of the gap. The entire droplet was observed to rotate. This experiment was repeated using other solutions such as ferric chloride, etc., with like results.

In another experiment, a microscope slide cover glass was floated on a solution of copper sulfate. One pole was immersed in the solution while the other was placed directly above the cover glass. Rotation of the entire solution caused the floating cover glass to rotate.

So far, the motions described have been those of particles in coarse suspension, bubbles and the motion of the entire liquid. The authors next studied the action of a magnetic field on true colloidal suspensions. In these experiments silver nitrate and sodium stearate were used. As before, rotational motions were observed. Large particles formed in the sodium stearate solution experiment and entered the space between the poles of the electromagnet with great speed, depositing on one or the other of the pole faces.

Another set of experiments was performed using the electromagnet and making observations of the action of copper sulfate, ferrous sulfate, ferrous ammonium sulfate, nickel nitrate, nickel sulfate, cobalt nitrate and cobalt sulfate solutions in a magnetic field. When these solutions were placed in a homogeneous magnetic field a slight luminous clouding effect was observed. In every case, this clouding first appeared near the upper pole, gradually dispersing and assuming the shape of a waterspout. Occasionally, striations were observed in the cloud. If copper particles were added to the copper sulfate solution, the copper particles were drawn into the waterspout formation and followed a spiral path down into the narrow portion of the formation.

In experiments using colloidal dispersions of copper, iron, nickel and manganese the dispersion was destroyed by a continued application of a homogeneous magnetic field. The dispersion was observed to gradually become "smoky" and finally disappear. Increasing the power of the microscope to 800X failed to disclose the presence of particles of any size.

The research work thus far has been of a largely qualitative nature. The authors hope to continue their investigations in the field and to make quantitative measurements and also to examine the possibility of a classical theoretical interpretation of the observed phenomena.

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SCIENTIFIC APPARATUS AND LABORATORY METHODS

THE BLOOD-SALINE COAGULATION TIME TEST

THE coagulation time of whole blood is influenced by mechanical agitation, temperature, foreign surfaces, air bubbles and the size and shape of containers in relation to blood volume. All coagulation time tests do not yield comparable readings because of these variable factors. The introduction of a new coagulation time test is justifiable only if it offers significant advantages over the multitude of methods available. We have developed a method which is based on the phenomenon, which we studied that whole blood diluted with physiologic saline delays the coagulation time. This method is subject to the same variable influences listed above. Furthermore, we found that a relation exists between the final concentration of blood in physiologic saline and the coagulation time, the latter becoming more prolonged in lower blood concentrations.

Four Pyrex glass tubes, 75×10 mm, are used in each test. One cc of physiologic saline is added to three of these tubes. Ten cc of blood are withdrawn from the antecubital vein and the needle removed. Since tissue juice, which may enter the syringe initially, affects the coagulation time,[1] only the 3 or 4 cc of blood which enter the syringe last are expelled into a large tube. From this tube 1 cc is then pipetted into the first tube which does not contain saline. Another 1 cc is pipetted into the second tube containing saline and aspirated well 3 times, care being taken to avoid the formation of bubbles. From this mixture 1 cc is pipetted into the third tube and the process of serial dilution carried out through the fourth tube from which 1 cc is discarded. The average time from the moment that the blood entered the syringe until the last dilution was made was found to be 92 seconds in 54 men, the longest interval being 115 seconds. The starting time was arbitrarily adopted as the time the blood first entered the syringe. It is important that all 4 tubes be tilted in the same manner and at the same interval of time. Therefore, as a rule, readings should be done every 30 seconds up to 15 minutes, and afterwards every 5 minutes until all samples have clotted. These reading times can be modified whenever hyper- or hypocoagulable blood is tested. Since it is known that changes in temperature can markedly alter the coagulation time, tests should be run at constant temperatures, preferably. We chose as the endpoint the appearance of a gel. In most cases this gel was firmly attached to the glass wall. However, in a number of instances, a sliding gel was formed in the tube containing the 12.5 per cent. blood concentration.

Table 1 gives the coagulation times obtained on fifty-four medical students and members of the faculty.

TABLE 1

BLOOD-SALINE COAGULATION TIMES IN FIFTY-FOUR HEALTHY MEN

Blood concentration Per cent.	Time in minutes at 33°C. Range	Average
100	3.0– 6.5	4.5
50	4.0– 10.5	5.5
25	5.5– 13.5	9.0
12.5	14.0–365.0	70.0

No patients with hemorrhagic diseases were available. One interesting observation noted was that in the 100 per cent. and 50 per cent. blood concentrations the coagulation times were approximately the same. However, the 50 per cent. blood samples frequently showed a slightly increased coagulation time. Perhaps the degree of coagulability may prove to be more properly evaluated in blood concentrations of 12.5 per cent.

This coagulation time test was applied to studies of dogs[2] in which hypocoagulability and hypercoagulability of blood had been produced experimentally. It was found that, in certain cases, hypercoagulability and hypocoagulability could be detected in the diluted blood samples, but not in undiluted blood. Hypercoagulability was indicated by shortened coagulation times in all blood concentrations. Hypocoagulability was found in the 50 per cent. blood samples. These exhibited markedly prolonged coagulation times, whereas the coagulation time of the undiluted blood was well within normal limits. These phenomena promise to reveal changes in the coagulability of whole blood which are not detectable by the present methods. In addition, it is significant that this principle of blood-saline dilution provides a new and simple method of isolating corpuscles and plasma constituents from whole blood without the use of any anticoagulants. Certain phases of this problem are under investigation.

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[1] J. J. Lalich and A. L. Copley, *Proc. Soc. Exp. Biol. Med.*, 51: 232, 1942.

[2] A. L. Copley. To be published.

A CONSTANT VACUUM APPARATUS

FREQUENTLY there is need in the laboratory for a device for regulating pressure derived from a house vacuum source to a constant level. An effective ap-

paratus which can be constructed simply and inexpensively from odds and ends is illustrated in Fig. 1.

The instrument is constructed on a base of $\frac{3}{4}$ inch boards. The base is 19½ inches long, 4 inches wide and 3½ inches high. Regulation of pressure is accomplished by the movement of the oiled plunger of a 20 cc syringe mounted horizontally as shown. The head of the plunger is attached by means of a bridle to the coil spring. The other end of the spring is fastened in turn to a rack and gear that can be moved to and fro through the influence of the knurled screw. Included in the bridle is the upper end of a metal lever passing down through a ½ by $\frac{7}{8}$ inch hole in the top of the base and fastened with a hinge at the other end, as shown. A tube of resilient rubber 3/16 inch internal diameter and 3/32 inch wall thickness is passed between the lever and the perpendicular block and fastened with metal loops screwed to the block. The rubber tube continues and joins a T tube of glass, one limb of which communicates by way of a short piece of rubber tubing to the syringe. The third limb of the T tube communicates distally with other apparatus where the constant vacuum is desired.

In operation, the spring pulls out the plunger, and at the same time pulls the lever away from the rubber tube leading from the house vacuum source. With the vacuum turned on, the full pressure is exerted throughout the system, including the syringe. When flow of air is interrupted in the distal parts of the system, the pressure falls inside the syringe, sucking in the plunger to an extent proportional to the degree of interruption of flow. When the plunger moves forward, so, too, does the lever, compressing the rubber tube between it and the perpendicular block. The air flow is then interrupted at this point to a degree depending on the tension of the spring and is stopped completely if tube to the apparatus is closed off. The interfering resiliency of the rubber tube is counteracted by the auxiliary second spring attached to the lever beneath the top board.

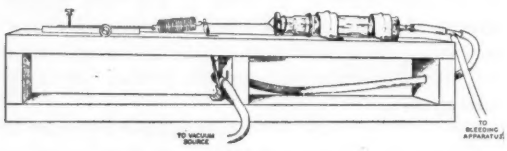

FIG. 1.

An example of the use of the device is in connection with the bleeding of chickens (or other small animals) from the heart into citrate solution. A special arrangement of syringe and needle for this purpose is shown in Fig. 2. For this a 50 cc syringe is fitted with a rubber stopper with two bends. One communicates through a short rubber tube and a short glass air jet (.010 inch diameter) with the long rubber tubing leading to the constant pressure device. The second bend reaches down the outside of the syringe to a sharp angle and the open end, which is glazed smooth. To the end of the syringe is fitted an adapter, into which a section of the shaft of a No. 16 gauge needle has been soldered, providing a means for holding the citrate solution in the syringe. For bleeding chickens a No. 18 gauge needle is fitted to the adapter.

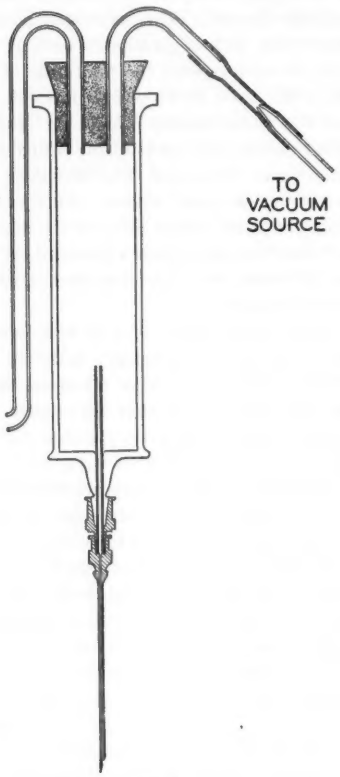

FIG. 2.

To use the device, the vacuum, regulated by the instrument of Fig. 1, is turned on. The needle is dipped into citrate solution and, with the index finger closing the open end of the downward bend, citrate solution is drawn into the syringe to a level somewhat below that of the needle projecting into the syringe. Then, with the end of the downward bend open, the needle is manipulated into the heart. When the blood shows, the opening of the downward bend is again closed with the finger, the vacuum at constant low pressure is exerted and the blood is drawn into the syringe.

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SCIENCE NEWS

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NEWSPAPERS BY RADIO

NEWSPAPERS printed in your own home may be a reality in the postwar world if new transmitting and receiving equipment now being offered to newspaper publishers comes into widespread use. Known for many years to engineers as facsimile, the system transmits eight full pages of tabloid-sized newspapers in one hour by radio from the newspaper office to receivers in the home.

Before the war, facsimile receivers cost about $75. Research, engineering and manufacturing studies made during the war should make it possible to offer these receivers, with wartime improvements, at an even lower cost.

At the newspaper office, news, maps, cartoons, advertisements, feature columns and other items that make up a newspaper are mounted on a sheet of paper, so that the end result looks the same as a page from a regular newspaper. This sheet of paper is fed into a machine, where is it scanned, line by line, by a photoelectric eye.

The scanning process does the same thing mechanically that you are doing right now as you read this story. It starts at one line, moving from left to right, then jumps to the next line and repeats the procedure, continuing until all the copy has been scanned.

Everything that the photo-eye sees is converted into electric impulses, then into radio waves by electronic tubes similar to those in a radio set. These tubes break up the picture seen by the electric eye into a series of dots, which are received in your home receiver approximately facsimile in size and at the same speed at which they are transmitted.

The printing is done by a swinging arm that moves back and forth across a roll of special white printing paper in the facsimile receiver, synchronized with the movement of the electric eye in the transmitter. A stylus at the tip of the moving arm sweeps across the paper, and by means of small electrical impulses oxidizes a series of dots in their proper sequence, just as the electric eye transmits them. The coating on the paper turns black on being oxidized, leaving a permanent record of the copy fed into the transmitter at the newspaper office.

The receiver can be turned on at a predetermined time, and after the printing is completed, it will go off, leaving the completed newspaper. All this can be done in the early morning hours while the subscriber sleeps, leaving the morning paper ready to be read at breakfast.

Several industrial companies are now actively engaged in postwar planning for facsimile. One of these concerns, Finch Telecommunications, of Passaic, N. J., has just secured the services of a consultant to advise newspaper publishers interested in the development of facsimile as a part of their activities.

In addition to daily newspapers, weather maps, flash news, pictures, police reports showing descriptions and pictures of criminals, reports to and from planes in the air, data for ships at sea and many other types of material may be transmitted and received by facsimile equipment. Facsimile makes use of the same radio frequencies as FM (frequency modulation) broadcasting. This means that the area over which transmission is practical is more or less confined to the area visible from a transmitter antenna. Therefore, unless networks for fascimile are developed, this service will be limited to local areas.

ITEMS

COPIES of diffraction gratings, glass or metal with closely spaced parallel lines ruled on it, used in many types of spectrographs, are even better than the original gratings from which they were made, as reported by Dr. R. W. Wood, of the Johns Hopkins University, in the *Journal* of the Optical Society of America. Coarse gratings of 1,000 to 7,000 lines to the inch, which are especially useful for analyzing infra-red light, are first ruled on copper plates which have been polished as well as possible but can not be made as flat as polished glass. The collodion cast or copy of the original grating will reproduce faithfully both the carefully ruled lines and the small irregularities of the surface of the copper plate. But when this replica is pressed into contact with a piece of optically flat plate glass, the imperfections on the surface are "ironed out," leaving the replica with better optical properties than the original. Studies of light spectra with these gratings not only extend our knowledge of the behavior of atoms, but also have practical applications such as the identification of impurities in chemicals and metals.

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ANTHRAX, for which no completely satisfactory treatment has yet been developed, may yield to penicillin, it appears from a report by Dr. F. R. Heilman and Dr. W. E. Herrell, of the Mayo Clinic at Rochester, Minn. In trials with mice, they found that slightly more than half the animals treated with penicillin could be protected against 10,000 times the lethal dose of anthrax germs even when treatment was not started until 16 hours after the mice had been inoculated with the germs. In other trials, starting treatment within an hour and inoculating fewer germs, all the treated mice survived and all the untreated ones died.

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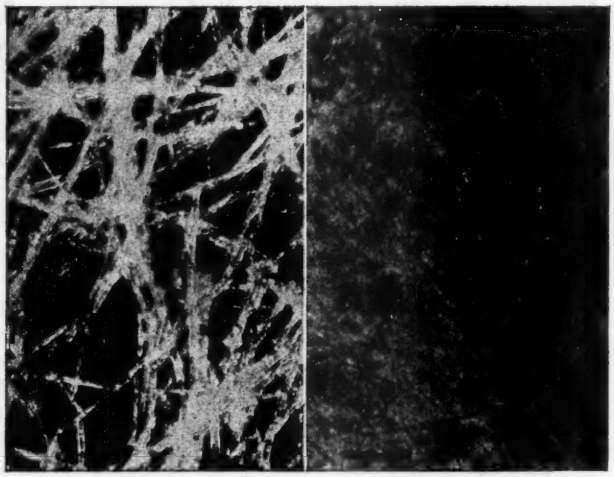

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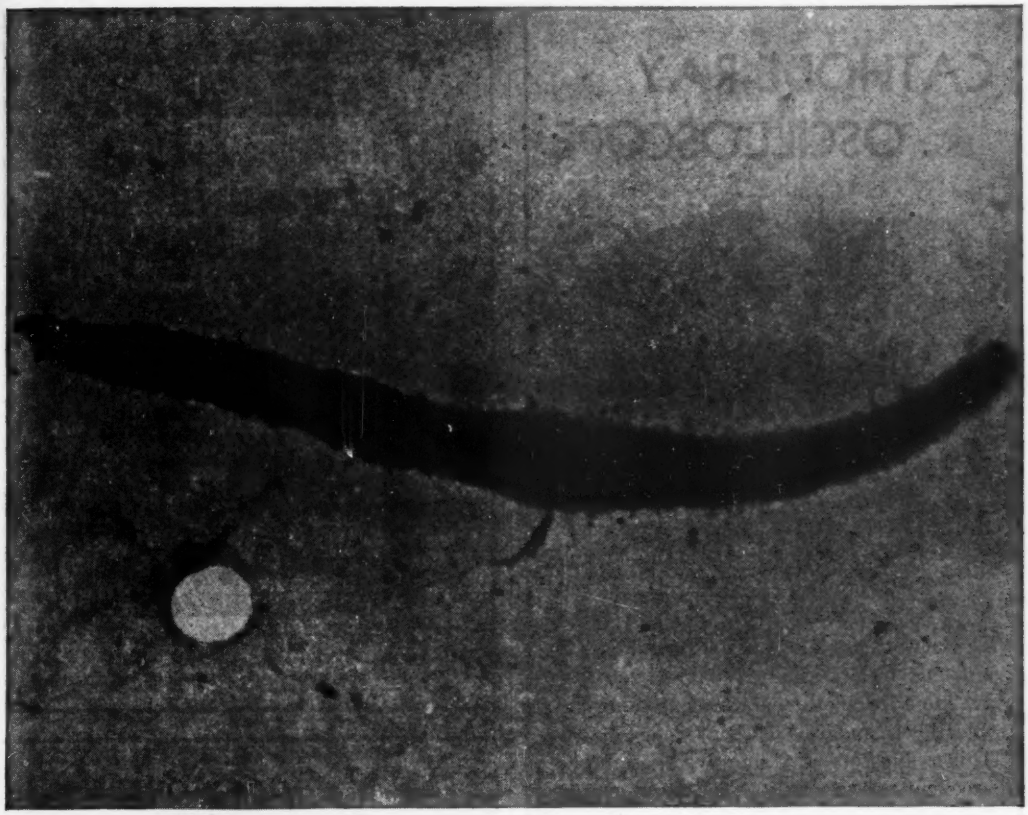

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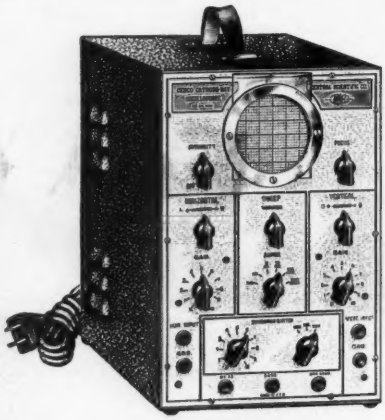

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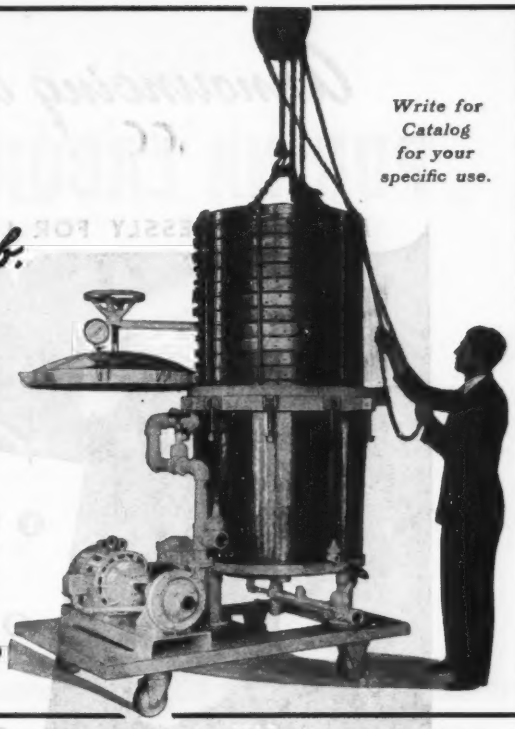

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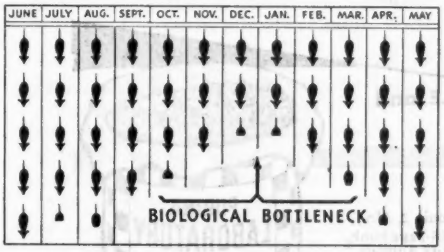

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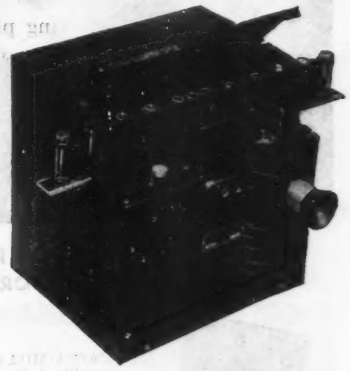

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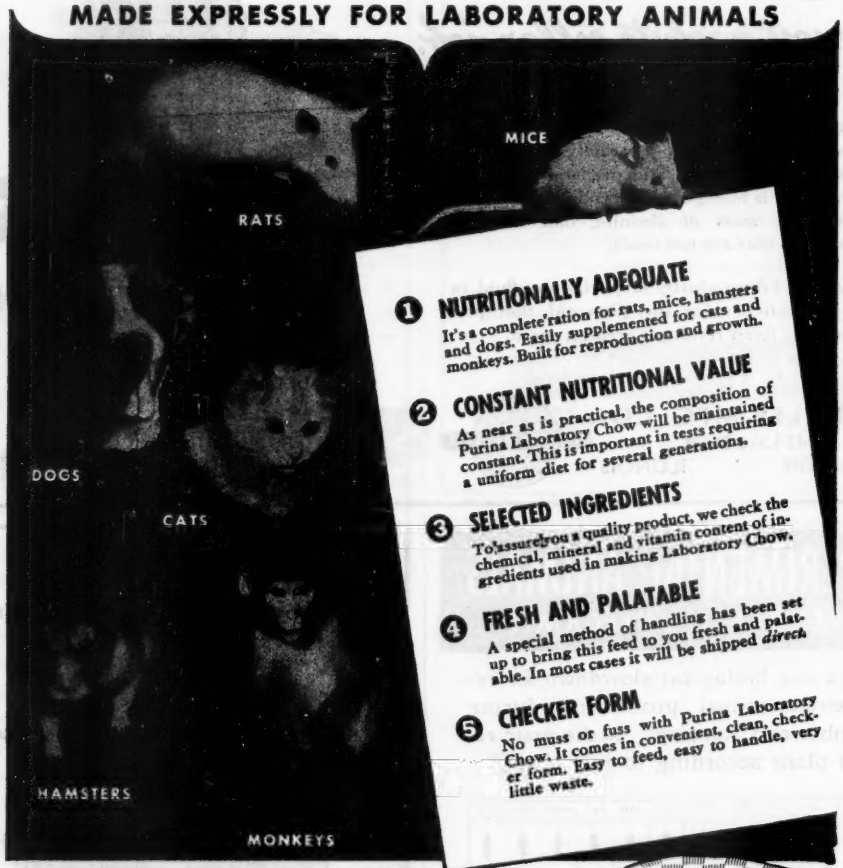

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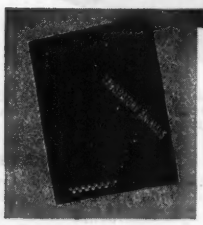

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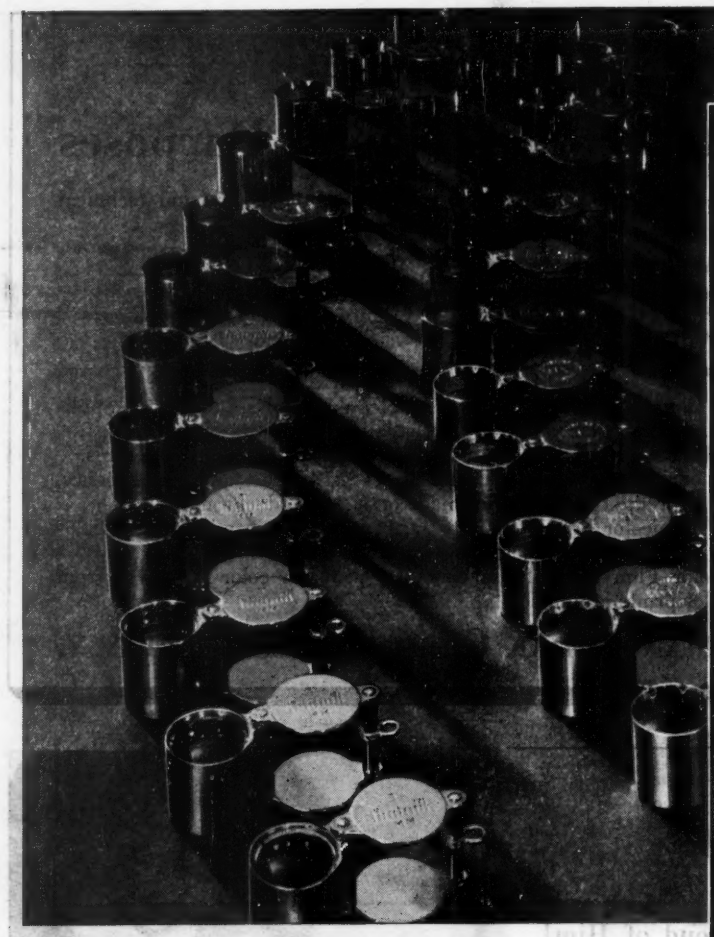

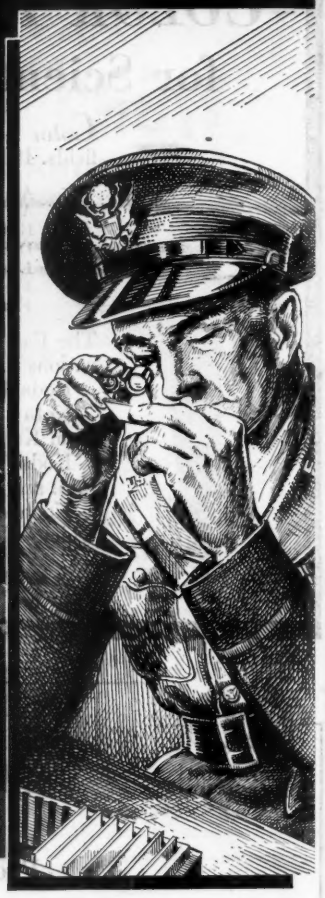

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